SHOUT
SHARE
IT

PROCEEDINGS

OF THE

Biological Society of Washington

VOLUME VIII.

1893.

WASHINGTON:
PRINTED FOR THE SOCIETY.
1893-95.

COMMITTEE ON PUBLICATIONS.

F. H. KNOWLTON, *Chairman.*

T. H. BEAN.

F. V. COVILLE.

L. O. HOWARD.

T. S. PALMER.

TERRY BROS., Printers.

CONTENTS.

	PAGE
Officers and Committees for 1893	iv
Joint Commission for 1893	iv
Proceedings	v–xiii
Addresses and Communications:	
A Jumping Mouse (Zapus insignis Miller) new to the United States. By Gerrit S. Miller, Jr.,	1
Paleontology of the Cretaceous Formations of Texas.—The Invertebrate Paleontology of the Trinity Division. By Robert T. Hill,	9
Further notes on Yucca Insects and Yucca Pollination. By C. V. Riley,	41
Description of a new White-footed Mouse from the Eastern United States. By Gerrit S. Miller, Jr.,	55
Development of the Brachial Supports in Dielasma and Zygospira. By Charles E. Beecher and Charles Schuchert. And on the Development of the Shell of Zygospira recurvirostra. By Charles Schuchert,	71
Re-discovery of the Mexican Kangaroo Rat, Dipodomys Phillipsi Gray. By C. Hart Merriam, M. D. With field notes by E. W. Nelson,	83
The Paleontology of the Cretaceous Formations of Texas.—The Invertebrate Fossils of the Caprina Limestone Beds. By Robert T. Hill,	97
Two new Wood-rats from the plateau region of Arizona (Neotoma pinetorum and N. Arizonæ), with remarks on the Validity of Genus Teonoma of Gray. By C. Hart Merriam, M. D.,	109
Notes on Thomomys bulbivorus. By Gerrit S. Miller, Jr.,	113
Description of a new Species of Lagomys from Alaska. By E. W. Nelson,	117
Juncus marginatus and its Varieties. By Frederick Vernon Coville,	121
Description of eight new Ground Squirrels of the genera Spermophilus and Tamias from California, Texas and Mexico. By C. Hart Merriam, M. D.,	129
Description of a new Species of Arvicola of the Mynomes group from Alaska. By E. W. Nelson,	139
Preliminary Descriptions of four new Mammals from Southern Mexico, collected by E. W. Nelson. By C. Hart Merriam, M. D.,	143
The Yellow Bear of Louisiana, Ursus luteolus Griffith. By C. Hart Merriam, M. D.,	147
Index,	153

24216

LIST OF THE OFFICERS AND COUNCIL

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

ELECTED DECEMBER 31, 1892.

OFFICERS.

PRESIDENT.

C. V. RILEY.

VICE-PRESIDENTS.

FRANK BAKER,
B. E. FERNOW,
RICHARD RATHBUN,
C. D. WALCOTT.

RECORDING SECRETARY.

F. V. COVILLE.

CORRESPONDING SECRETARY.

F. A. LUCAS.

TREASURER.

FRANK H. KNOWLTON.

COUNCIL.

TARLETON H. BEAN,
WILLIAM H. DALL,*
THEODORE GILL,*
G. BROWN GOODE,*
L. O. HOWARD,
C. HART MERRIAM,*
T. S. PALMER,
THEOBALD SMITH,
FREDERICK W. TRUE,
LESTER F. WARD.*

STANDING COMMITTEES—1893.

Committee on Communications.

B. E. FERNOW, *Chairman.*
CHARLES SCHUCHERT,
ERWIN F. SMITH.

Committee on Publications.

THEODORE GILL, *Chairman.*
L. O. HOWARD,
FRANK H. KNOWLTON,
T. W. STANTON,
GEO. B. SUDWORTH.

Committee on Trees and Shrubs.

LESTER F. WARD, *Chairman.*
F. V. COVILLE,
THEODORE HOLM,
FRANK H. KNOWLTON.

Delegates to the Joint Commission of Scientific Societies of Washington.

RICHARD RATHBUN,
C. V. RILEY,
LESTER F. WARD.

*Ex-Presidents of the Society.

PROCEEDINGS.

Two Hundred and Fourth Meeting,

January 14, 1893.

Vice-President Dr. Baker in the chair, and thirty-one members present.

Mr. Walter H. Evans was elected an active member.

Dr. Erwin F. Smith presented a paper entitled Additional Notes on Peach Rosette.*

Mr. D. G. Fairchild presented some Notes on Apple and Pear Fusicladii. The paper was discussed by Messrs. Erwin F. Smith and Waite.

Prof. L. F. Ward spoke upon The New Botany.† Prof. Ward's communication was discussed by Dr. Baker.

Drs. Theobald Smith and V. A. Moore followed with a communication upon The Growth of Bacteria through the Pasteur-Chamberland Filter.‡

Two Hundred and Fifth Meeting,

January 28, 1893.

Mr. L. O. Howard in the chair, and thirty-one persons present.

Messrs. D. D. Luke and H. H. Doubleday were elected active members.

Prof. Robert T. Hill presented some Notes on the Paleontology of the Comanche Series.§ The paper was discussed by Messrs. Stanton and Ward.

---

*Journal of Mycology, vii, pp. 226–232, 1893.

†Science, N. Y., xxi, pp. 43–44, Jan. 27.

‡Zur Prüfung der Pasteur-Chamberland Filter, <Centralblatt f. Bakteriologie und Parasitenkunde, xii, pp. 628–629, 1892.

§Paleontology of the Cretaceous Formations of Texas.—The Invertebrate Paleontology of the Trinity Divisions. <Proc. Biol. Soc. Wash., Vol. viii, pp. 9–40, pls. i–viii, 1893.

Prof. L. F. Ward spoke upon The Flora of the Trinity Division on the Comanche Series in Texas, exhibiting specimens and a manuscript and drawings prepared by Prof. W. M. Fontaine.* Prof. Ward's communication was discussed by Messrs. Stanton and Hill.

Mr. C. H. Townsend read a paper entitled Sea-Otter Fishing in Alaska in Relation to the Natives, which was discussed by Messrs. Sheldon Jackson, Dall, Evermann, and Merriam.

Two Hundred and Sixth Meeting,

February 11, 1893.

The President in the chair, and thirty-four persons present.

Mr. M. B. Waite presented a communication on The Destruction of Lichens on Pear Trees.†

Mr. Charles Hallock read a paper on The Geographical Distribution of the Musk-Ox.

Mr. C. H. Townsend spoke upon The Propagation of the Atlantic Coast Oyster on the Pacific Coast. The paper was discussed by Mr. Dall and Mr. Van Deman.

Mr. G. S. Miller exhibited a specimen of A New Jumping Mouse (*Zapus insignis*).‡

Dr. C. Hart Merriam spoke upon The Four-toed Kangaroo Rats.

Two Hundred and Seventh Meeting,

February 25, 1893.

The President in the chair, and forty-seven persons present.

---

*W. M. Fontaine—Notes on some Fossil Plants from the Trinity Division of the Comanche Series. <Proc. U. S. Nat. Mus., Vol. xvi, pp. 261–285, pls. xxxvi–xliii, 1893.

†Experiments with Fungicides in the removal of Lichens from Pear Trees. <Journal of Mycology, Vol. vii, No. 3, pp. 264–268, pls. xxx–xxxi, 1893.

‡A Jumping Mouse (*Zapus insignis* Miller) new to the United States. <Proc. Biol. Soc. Wash., Vol. viii, pp. 1–8. (Extras issued April 22, 1893.)

Dr. Nordqvist of Finland was present as a guest of the Society.

The Rev. Sheldon Jackson spoke on THE INTRODUCTION OF REINDEER IN ALASKA.* The subject was further discussed by Messrs. Gill, Stejneger, Merriam, Dall, Evermann, Townsend and Nordfeldt.

Mr. M. B. Waite treated of THE VARIATION OF THE FRUIT OF THE PEAR DUE TO DIFFERENCE OF POLLEN.†

Mr. E. M. Hasbrouck read a paper ON THE DEVELOPMENT OF THE APPENDAGES OF THE CEDAR WAX WING.‡

Mr. F. A. Lucas read an article on THE FOOD OF HUMMING BIRDS.§

TWO HUNDRED AND EIGHTH MEETING,

March 11, 1893.

The President in the chair, and forty-eight members present.

Messrs. Outram Bangs of Boston, Mass., Herbert Brown of Tucson, Arizona, and Miss Florence A. Merriam of Locust Grove, N. J., were elected corresponding members.

Dr. Frank Baker read a paper entitled RECENT DISCOVERIES IN THE NERVOUS SYSTEM.‖ The subject was further discussed by Dr. Wm. A. Hammond and Prof. Ward.

Mr. Vernon Bailey spoke upon THE BURROWS OF FIVE-TOED KANGAROO RATS, which called forth remarks from Messrs. Baker, Bailey, Merriam and Coville.

---

*Report on Introduction of Domestic Reindeer into Alaska, with Maps and Illustrations. <Misc. Doc. No. 22, 52nd Congress, 2nd Session, 39 pp., Washington, D. C., 1893.

†Effects of Different Kinds of Pollen on the Character of the Fruit (Chap. v of the Pollination of Pear Flowers). <Bull. No. 5, Div. Veg. Path., U. S. Dept. Agric., pp. 55–74, Pls. i–xii, 1894.

‡A presumably new fact relative to the Cedar Wax wing (*Ampelis cedrorum*), with remarks upon the importance of a thorough knowledge of first plumages. <Science, N. Y., xxi, pp. 144, 145, March 17, 1893.

§The Auk, Vol. x, pp. 311–315, Oct. 1893.

‖The New York Medical Journal, lvii, pp. 657–663, 685–692, figs. 1–28, June 17 and 24, 1893.

Mr. E. M. Hasbrouck gave a communication on The Breeding of the Bald Eagle near Mount Vernon, with an exhibition of eggs. Comments were made by Messrs. John Burroughs and Ward.

Two Hundred and Ninth Meeting,

March 25, 1893.

The President in the chair, and thirty-five members present.

Dr. William C. Rives of New York was elected a corresponding member.

The President announced the death of Dr. George Vasey, Botanist of the Department of Agriculture, and of Dr. Henry Clay Nelson, United States Army, both members of the Society. On motion by Mr. Walcott, it was voted to appoint some member to present a biographical sketch of Dr. Vasey. The President appointed Mr. Coville.

L. M. McCormick presented a paper on A Hybrid Between Pyranga rubra and Pyranga erythromelas.* The paper was discussed by Messrs. Howard and McCormick.

Prof. E. W. Doran read an article on the Development of the Intestines of Tadpoles. Remarks were made upon the subject by Messrs. Dall, Riley, and Reyburn.

Dr. Theobald Smith addressed the Society on The Bacteriology of Potomac Water and its Bearing upon Sanitary Problems. This paper gave rise to a long discussion, in which Messrs. Lucas, Dall, Reyburn, Howard, Waite, Riley, and Smith participated.

Two Hundred and Tenth Meeting,

April 8, 1893.

Dr. C. Hart Merriam in the chair, and twenty-five persons present.

---

*The Auk, Vol. x, pp. 302–303, July, 1893.

Mr. F. V. Coville spoke upon the Characteristics and Adaptations of a Desert Flora.* Remarks followed upon the same subject by Messrs. Smith and Evans.

Mr. C. W. Stiles discussed The Cause of Measly Duck,† exhibiting microscopic specimens of the disease and the parasite causing it. The subject was further discussed by Messrs. Merriam, Th. Smith, and Gurley.

Dr. R. R. Gurley read a paper on Natural Selection as Exemplified by the Cackling of Hens, which was discussed by Messrs. Lucas and Van Deman.

Prof. J. W. Chickering spoke upon The Botanical Landscape.‡ His paper was discussed by Messrs. Merriam and Lucas.

Two Hundred and Eleventh Meeting,

April 22, 1893.

The President in the chair, and thirty persons present.

Mr. O. F. Cook presented Notes on the Natural History of Liberia. Mr. Cook's communication was discussed by Dr. Gill.

Mr. J. N. Rose treated of Two Trees of Economic Importance from Mexico.§

Dr. V. A. Moore made Observations on the Distribution and Specific Character of the Streptococci Group of Bacteria. The subject was discussed by Dr. Th. Smith.

---

*A chapter of botany of the Death Valley Expedition. <Contributions from the U. S. National Herbarium, Vol. ix, pp. 33–55, 1893.

†Notes on Parasites—18: On the Presence of Sarcosporidia in Birds. <Bull. Bur. An. Indust., No 3, U. S. Dept. Agric., pp. 79–88, pls. ii–iii.

‡Science, N. Y., xxiii, pp. 118–119, March 2, 1894.

§A new *Tubebuia* from Mexico and Central America: *Tubebuia Donnell-Smithii*. <Bot. Gaz., Vol. xvii, pp. 418–419. A new *Bumelia* from Mexico (B. Palmeri). <Garden and Forest, vii, p. 195, 1894.

‖Observations on the Morphology, Biology, and Pathogenic Properties of twenty-eight Streptococci found in the investigations of Animal Diseases. <Bull. Bur. An. Industry, No. 3 (U. S. Dept. Agric.), pp. 9–30, 1893.

Dr. Erwin F. Smith considered Peach Yellows and Plant Nutrition.*

Two Hundred and Twelfth Meeting,

May 6, 1893.

The President in the chair, and nine persons present.

L. H. Dewey presented a paper entitled Geographic Distribution of Grasses in the United States. Mr. Dewey's article was discussed by Messrs. Coville and Palmer.

Dr. Erwin F. Smith spoke On the Symbiosis of Stock and Graft. Further remarks upon the same subject were made by Messrs. Coville, Riley, and the original speaker.

Dr. Theobald Smith described A New Sporozoon in the Intestinal Villi of the Ox.†

The Communication was discussed by Messrs. E. F. Smith, Riley, and Theobald Smith.

Two Hundred and Thirteenth Meeting,

May 20, 1893.

The President in the chair, and twenty-eight persons present.

Mr. Charles Schuchert was elected an active member.

The following communications were presented.

Dr. V. A. Moore read on The Distribution of Pathogenic Bacteria in the Upper Air Passages of Domesticated Animals.‡

---

*Experiments with Fertilizers for the Prevention and Cure of Peach Yellows, 1889–92. <Bull. Div. Veg. Path., No. 4, U. S. Dept. Agric., 197, p. 33, pl., 1893.

†Preliminary Notes on a Sporozoön in the Intestinal Villi of Cattle. <Bull. Bur. An. Indust., No. 3 (U. S. Dept. Agric.) pp. 73–78, pl. i, 1893.

‡Pathogenic and Toxicogenic Bacteria in the Upper Air Passages of Domesticated Animals. <Bul. Bur. An. Ind., No. 3, (U. S. Dept. Agric.) pp. 31–48, 1893.

Prof. C. V. Riley gave some Further Notes on Yucca Pollination.* Prof. Riley's communication was discussed by Messrs. Howard and Riley.

Prof. Barton W. Evermann spoke of The Ichthyologic Features of the Black Hills.†

Mr. Wm. H. Dall discussed New Forms of Fossils from the Old Miocene of the Gulf States.

Dr. C. Hart Merriam treated of Biology in our Colleges.‡ The paper was discussed by Messrs. Ward, Burgess, and Riley.

Two Hundred and Fourteenth Meeting,

October 21, 1893.

The President in the chair, and thirty persons present.

Mr. Charles Torrey Simpson was elected an active member.

Prof. Lester F. Ward presented a communication entitled Weismann's Concessions. Prof. Ward's communication was discussed by Messrs. Riley, Dall, Schaeffer, Gill, Coville, and Ward.

Dr. C. Hart Merriam and Vernon Bailey presented some Notes on a Biological Reconnoisance of Wyoming.

Two Hundred and Fifteenth Meeting,

November 4, 1893.

The President in the chair, and twenty-three members present.

Mr. W. T. Swingle considered Some Problems of Plant Geography in Florida.

---

*Further Notes on Yucca Insects and Yucca Pollination. <Insect Life, Vol. v, pp. 300–310, (pl. ii and fig. 38, *a–g*). Also <Proc. Biol. Soc. Wash., Vol. viii, pp. 41–54, pl. ix.

†Proc. Indiana Acad. Sc. for 1892, pp. 73–78 (Abstract).

‡Biology in our Colleges: A Plea for a Broader and more liberal Biology. <Science, N. Y., xxi, pp. 352–355, June 30, 1893.

Dr. C. Hart Merriam spoke on THE FAUNA AND FLORA OF EASTERN WYOMING. Messrs. Rose, Coville, Evermann, and Merriam made informal remarks upon the same subject.

Dr. C. W. Stiles treated of ARTIFICIAL SPECIES OF CESTODES.* This paper was discussed by Messrs. Dall, Merriam, Gill, Fernow and Riley.

TWO HUNDRED AND SIXTEENTH MEETING,

November 18, 1893.

The President in the chair, and thirty-seven persons present.

Mr. Wm. H. Ashmead and Mr. F. C. Pratt were elected active members.

Dr. C. Hart Merriam presented a communication entitled REMARKS ON THE GENUS GEOMYS.† Dr. Merriam's paper was discussed by Messrs. Gill, Ward, Riley, and Merriam.

Mr. Frederick V. Coville spoke upon JUNCUS MARGINATUS AND ITS VARITIES.‡

The question WHAT ARE THE SPECIAL NEEDS OF THE BIOLOGICAL SOCIETY OF WASHINGTON? was discussed by Messrs. Fernow, Stiles, Gill, and Merriam.

TWO HUNDRED AND SEVENTEENTH MEETING,

December 2, 1893.

Dr. Gill in the chair, and twenty-four persons present.

Mr. J. B. Thompson of Washington was elected an active member.

Mr. F. H. Blodgett read NOTES ON THE DEVELOPMENT OF

---

*A Revision of the Adult Cestodes of Cattle, Sheep and allied Animals. <Bur. An. Ind. (U. S. Dept. Agric.) Bul. No. 4, pp. 97–101.

†Monographic Revision of the Pocket Gopher's Family, Geomyidæ. (North America Fauna, No. 8) 1895.

‡Proc. Biol. Soc. Wash., pp. 121–128

THE BULB OF THE ADDER'S TONGUE. The subject was discussed by Messrs. Ward, Burgess, and Seaman.

Mr. E. W. Nelson commented on A NEW SPECIES OF LAGOMYS FROM ALASKA.*

Dr. Erwin F. Smith spoke of A BACTERIAL DISEASE OF CUCUMBERS, ETC., WORKING THROUGH THE FIBROVASCULAR BUNDLES AND PROBABLY TRANSMITTED BY INSECTS.† The paper was discussed by Messrs. Seaman and Galloway.

TWO HUNDRED AND EIGHTEENTH MEETING,

December 16, 1893.

Mr. Rathbun in the chair, and thirty persons present.

The evening was given up to short miscellaneous communications.

TWO HUNDRED AND NINETEENTH MEETING,

December 30, 1893.

The President in the chair, and twenty-two members present.

Surg. Gen. Geo. M. Sternberg and Mr. Filibert Roth were elected active members.

The annual reports of the Secretary and Treasurer were read and accepted and officers for the year 1894 were elected as follows:

President, C. V. Riley; *Vice-Presidents*, Frank Baker, B. E. Fernow, Richard Rathbun, C. D. Walcott; *Recording Secretary*, C. W. Stiles; *Corresponding Secretary*, F. A. Lucas; *Treasurer*, F. H. Knowlton; *Councilors*, T. H. Bean, L. O. Howard, T. S. Palmer, Theobald Smith, F. W. True.

---

*Description of a New Species of Lagomys from Alaska. <Proc. Biol. Soc. Wash., viii, pp. 117–120.

†A Bacterial Disease of Cucumbers, Cantaloupes and Squashes (Abstract). <Proc. Am. Ass. Adv. Sc. for 1893, p. 259, 1894.

VOL. VIII, PP. 1-8 APRIL 22, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

A JUMPING MOUSE (*ZAPUS INSIGNIS* MILLER), NEW TO THE UNITED STATES.

BY GERRIT S. MILLER, JR.

Zapus insignis, hitherto known only from New Brunswick and Nova Scotia,* is locally common in the eastern United States, and will probably be found to be very generally distributed in the eastern part of the Canadian fauna. The specimens that have thus far come to my notice number forty-two. Of these, the type and two others were collected by E. A. Bangs on the Restigouche river, New Brunswick, in September, 1880; one was taken in Northumberland county, N. B., in June, 1892, by Gerrit S. Miller, and two (Nos. 4061 and 5785, collection of Dr. C. Hart Merriam) were collected at Godbout, P. Q., Canada, by Napoleon A. Comeau. The remainder were taken in the United States, as follows: Eleven by Mr. Frank Bolles at Chocorua, N. H., in September, 1892; two by Mr. C. F. Batchelder at Keene, Essex county, N. Y., in August, 1890; four at Elizabethtown, Essex county, N. Y., and nineteen at Peterboro, Madison county, N. Y., by the writer during the spring and summer of 1892.

With the possible exception of Mr. Comeau's specimens, of whose history I am ignorant, these were all taken in the woods, and generally close to water. The banks of running streams are

*See American Naturalist, XXV, August, 1891, 472.

especially attractive to these animals; many that I have caught actually sprang into the water in their death struggles. In such places they may be taken without difficulty in traps baited with rolled oatmeal, after these have been left in one place long enough to thin out the white-footed mice and short-tailed shrews. In my experience *Zapus insignis* is wholly a dweller in deep woods, never venturing out into grass fields and damp pastures, such as *Z. hudsonius* delights in, and avoiding thinly wooded places in general. *Zapus hudsonius*, on the other hand, seldom penetrates far into the woods, and the two species are not often found together, though I have several times taken both in the same traps on successive days, near the edge of some meadow or clearing. Dawson states that both kinds of jumping mice are found in grain fields near Halifax and Pictou, N. S. He adds, however, that the smaller species (*i. e.*, *Z. hudsonius*) is in such places much the more common and easily observed.

The original description of this species, based on three specimens somewhat faded by grease and age, was necessarily incomplete, and in some respects misleading. Hence it seems advisable to redescribe the animal, that there may be no future difficulty in recognizing it.

Zapus insignis Miller.

Meriones labradorius Dawson. Edinburgh New Phil. Journ., iii, 1856, 2.

Zapus insignis Miller. American Naturalist, xxv, August, 1891, 472.

Sp. Ch. Larger than *Zapus hudsonius* Zimmerman, with longer ears and paler, more fulvous coloration; tail when uninjured always tipped with white; teeth, i. $\frac{1-1}{1-1}$, pm. $\frac{0-0}{0-0}$, m. $\frac{3-3}{3-3}$ = 16.

Adult male (No. $\frac{1656}{1452}$, collection of G. S. Miller, Jr., Peterboro, N. Y., August 22, 1892); length, 250; tail vertebræ, 154; hind foot, 31.6; ear from notch, 18.6. Tip of tail for 23 mm., dorsum of manus and pes, and entire ventral surface pure white to base of hairs; sides buff-yellow, tinged with clay color, except on cheeks, fore neck, and a narrow line bordering white of belly, where the yellow is noticeably purer; the fur plumbeous gray at base and a trifle sprinkled with blackish bristly hairs. These blackish hairs predominate on the back, where they form a sharply defined dorsal stripe slightly mixed with the color of the sides, broadest just back of the shoulders, tapering gradually

to base of tail, and becoming indistinct on the head after passing between the ears. Ears externally concolor with back, internally buff-yellow; muzzle grayish brown; whiskers mixed brownish and whitish, the longest hairs reaching beyond shoulders; tail thinly haired, so that the annulation shows distinctly, sharply bicolor, dark brown, except ventrally and at tip.

Among the specimens of *Zapus insignis* that I have examined I find but little individual variation in color. That which occurs seems to be due chiefly to season, spring specimens having the sides brighter fulvous than those taken in the autumn and late summer. The dorsal stripe is darker and more sharply defined in some specimens than in others, the variation being caused by the relative quantities of blackish and fulvous hairs. In specimens with perfect tails the extent of the white tip varies from 30 mm. down to a mere trace; but the latter condition is rare, occurring only twice in the series before me, most tails showing from 10 mm. to 20 mm. of white.

The four males taken at Elizabethtown, N. Y., in April are brighter colored than the type and have apparently longer ears. These discrepancies are probably due entirely to the different condition of the specimens. Skins taken at Peterboro, N. Y., late in August and early in September are nearly as dull as the three from Restigouche, while the June specimen from Northumberland county, N. B., less than one hundred miles from the type locality, is fully as bright as any that I have seen. This specimen (No. 1438) is alcoholic, but the comparison was made a few days after its capture. The ear of No. 1438 is somewhat longer than that of an alcoholic specimen (No. 2000) from Peterboro, while the ears of Mr. Batchelder's specimens from Keene, N. Y., measure dry only a trifle more than the ears of the Restigouche skins.

On comparing thirty-eight skins of *Zapus insignis* with about one hundred specimens of *Z. hudsonius* from various parts of New Brunswick and the eastern United States, the paler, more fulvous coloration of the former at once strikes the eye. The ground color of the lateral stripe in *hudsonius* is more strongly tinged with clay color and is much more plentifully interspersed with black bristly hairs. There is no tendency in *hudsonius* to form the clear yellow area on the sides of the head and fore neck so conspicuous in *Z. insignis*. In the former, however, the clear yellow line separating the lateral stripe from the white of the

belly is apt to be more strongly defined and of a somewhat darker shade. *Z. insignis* is always pure white beneath, never showing a trace of the buffy suffusion commonly seen in *Z. hudsonius*. Yellow is the prevailing color on the head of *insignis*, while in *hudsonius* the black hairs are the more numerous on the head and face. The gray muzzle is much paler in *insignis* than in *hudsonius*. The ears of the two species differ notably in color as well as in size, those of *Z. hudsonius* being more thickly haired and blackish throughout, except for a sprinkling of yellowish hairs on the outside and a narrow, pale—sometimes white—border, while in *Z. insignis* the ears are lined with yellow and clothed outside with dusky and yellow hairs in about equal proportions, the latter forming a pale though never white edging.

Two young examples of *Z. hudsonius* (♂ *juv.* No. $\frac{16355}{14332}$ and ♂ *juv.* No. $\frac{16356}{14333}$, Peterboro, N. Y., August 1, 1892), otherwise perfectly typical, have 8 mm. of the distal end of the tail white. These are the only specimens of the species in which I have seen the slightest indication of this character, but it is to be expected since most of our small mammals occasionally have white-tipped tails. I have repeatedly noticed it in two races of *Sitomys americanus*; also occasionally in *Mus musculus*, *Arvicola riparius*, and *Blarina brevicauda*. It is thus especially noteworthy that in *Zapus insignis* this character, elsewhere merely accidental, should have become so fixed as to be practically diagnostic.

The skull of *Zapus insignis* closely resembles that of *Z. hudsonius*, but is throughout slightly broader and heavier, with a less highly arched brain case. Except for its somewhat larger size, the mandible shows no points of difference.

The teeth are all somewhat heavier than in *Z. hudsonius* and the crown of the middle upper molar appears in some specimens slightly longer proportionally.

In the original description of *Z. insignis* it was suggested that the absence of the premolar might be due to the age of the specimens at hand and consequent shedding of the tooth. That this view is incorrect is conclusively shown by the material now available. Specimens of *Z. hudsonius* with teeth excessively worn still retain the premolar, while in *Z. insignis* I have never found a trace of this tooth, even in individuals so young that the posterior molar has not cut through the gums. I have seen

but one specimen of *Z. hudsonius* in which the premolar is absent. This I suppose to be the skull from Pennsylvania referred to, on the authority of Mr. F. W. True, in the original description of *Z. insignis*. The specimen (No. $\frac{1684}{558}$, United States National Museum, Upper Darby, Pa.) is in a very fragmentary condition, but one tooth row remaining *in situ*, and the maxilla being broken off close to the roots of the first molar. Under these circumstances no weight can be placed on the fact that the premolar is not to be found.

Measurements of Forty Specimens of Zapus insignis.

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Hind foot.	Ear from notch.	Measured.
Skin.	Skull.								
464	387	Restigouche river, N. B.	Sept. 10, '80	♀	225	126	30	12.8	Dry.*
1	.....	" "	" 8, '80	♂	224	141	30.8	13	" †
4	.....	" "	" 10, '80	♂♂	235	140	30.4	14	"
1438	.....	Northumberland Co., N. B.	June 2, '92	♂♂	218	125	30	16.4	In alcohol.
4061	.....	Godbout, P. Q., Canada.	Aug. 27, '85	♀	240	158	32	.....	" ‡
5785	.....	" "	June 10, '85	♂	250	160	32.5	.....	"
2	.....	Keene, Essex Co., N. Y.	Aug. 8, '90	♂	.....	.....	29.6	14.6	Dry.§
8	.....	" "	" 10, '90	♂♂	.....	.....	31	14.2	"
1376	1192	Elizabethtown, Essex Co., N. Y.	April 3, '92	♂♂	242	147	30.5	18	Fresh.
1377	1193	" "	" 9, '92	♂♂♂	238	146	30.8	18	"
1378	1194	" "	" 10, '92	♂♂	....	157	32.4	18	"
1379	1195	" "	" 13, '92	♂♂♂	253	157.5	32	17.5	"
1647	1443	Peterboro, Madison Co., N. Y.	Aug. 17, '92	♂	235	146	31.4	17	"
1656	1452	" "	" 22, '92	♂♂	250	157	31.6	18.6	"
1657	1453	" "	" 23, '92	♂♂♂	253	158	32	17.8	"
1658	1454	" "	" 23, '92	♂♂♂	240	146	31	17.8	"
1659	1455	" "	" 23, '92	♂♂♂	243	150	31	17.6	"
1660	1456	" "	" 23, '92	♂♂♀	234	146	30.8	17	"
1664	1460	" "	" 25, '92	♂♀♀	239	145	29.8	17.2	"
1665	1461	" "	" 25, '92	♂♀♀	235	144	32	17	"
1666	1462	" "	" 25, '92	♂♂♀	225	148	32.2	18	"
1667	1463	" "	" 25, '92	♂♂♀	235	142	30	17	"
1673	1468	" "	" 29, '92	♂♀♀	240	148	30	16.6	"
1674	1469	" "	" 29, '92	♂♀♀	237	142	30	17.2	"
1675	1470	" "	" 29, '92	♂♀♀	228	133	30	17	"
1676	1471	" "	" 29, '92	♂♂♀	245	152	31.6	18	"
1677	1472	" "	" 29, '92	♂♂♀	230	142	30	17	"
1682	1477	" "	Sept. 9, '92	♂♀♀	231	143	29	16.6	"
1713	1504	" "	" 23, '92	♂♂♀	235	141	31	17.4	"
2000	.....	" "	Oct. 18, '92	♀	225	138	30	15.8	In alcohol.
1972	.....	Chocorua, Carroll Co., N. H.	Sept., 1892	....	.....	144	29.4	15	Dry.
1973	.....	" "	" "	....	...	147	31	15.6	"
1974	.....	" "	" "	....	.....	134	29.8	14	"
1975	.....	" "	" "	....	.....	138	29.8	15	"
1976	.....	" "	" "	....	.....	138	30	16	"
1977	.....	" "	" "	....	.....	138	28	15	"
1978	.....	" "	" "	....	.....	157	31	16	"
1979	.....	" "	" "	....	....	146	30.4	15.4	"
1980	.....	" "	" "	....	.....	143	30.4	16.4	"
1981	.....	" "	" "	....	.....	150	30.4	16	"

*Type.
†Collection of E. A. and O. Bangs.
‡Collection of Dr. C. Hart Merriam.
§Collection of Chas. F. Batchelder.

Measurements of Forty Specimens of Zapus hudsonius.

Number.		Locality.	Date.	Sex.	Total length.	Head and body.	Tail vertebræ.	Hind foot.	Ear from notch.
Skin.	Skull.								
787	.....	Oak Bay, N. B.....	Sept. 19, '91	....	241	.....	148	33	13 *
1414	.....	" "	Oct. 7, '91	....	190	.....	114	28	11
1836	1614	" "	.....	♀	215	.....	134	31.4	12.4
1840	1618	" "	.....	♀	203	.....	132	31	11
1841	1619	" "	.....	♂	215	.....	138	30.6	11.6
1842	1620	" "	.....	♂	215	.....	135	31	11
1846	1624	" "	.....	♂	225	.....	140	32	11
583	517	Peterboro, Madison Co., N. Y.	July 17, '91	♂	217	.....	134	30	12
584	518	" "	" 17, '91	♀	198	.....	143	31.2	12.8
585	519	" "	" 17, '91	♀	217	.....	132	30	11.8
586	520	" "	" 17, '91	♀	214	.....	135	31.6	13
587	521	" "	" 17, '91	♀	221	.....	142	31.5	12.8
588	522	" "	" 17, '91	♀	216	.....	139	30	13.4
620	538	" "	" 20, '91	♀	208	.....	128	29.6	12.2
622	539	" "	" 21, '91	♂	185	.....	116	29.5	10.5
623	540	" "	" 21, '91	♀	217	.....	127	28.8	13
624	541	" "	" 21, '91	♀	215	.....	137	30.4	12.4
625	542	" "	" 21, '91	♀	231	.....	152	31.4	13
626	543	" "	" 21, '91	♀	214	.....	129	30	12
627	544	" "	" 21, '91	♀	219	.....	132	30.6	11.4
628	545	" "	" 21, '91	♂	194	.....	122	27.5	12
630	546	" "	" 21, '91	♂	209	.....	128	29	11.4
631	547	" "	" 21, '91	♂	200	.....	122	28	11
1622	1419	" "	" 30, '92	♂	215	.....	124	31	14.6
1635	1432	" "	Aug. 1, '92	♂	205	.....	131	30.4	13
1636	1433	" "	" 1, '92	♂	200	.....	128	30	12.8
1646	1442	" "	" 9, '92	♀	202	.....	120	29	13.8
1650	1446	" "	" 18, '92	♂	203	.....	125	28	13
1663	1459	" "	" 25, '92	♂	203	.....	124	28	13
1669	1464	" "	" 26, '92	♀	198	.....	121	28	12.8
1679	1474	" "	Sept. 7, '92	♂	198	.....	118	29.6	13.8
1703	1495	" "	" 17, '92	♂	229	.....	129	30.8	14.4
1704	1496	" "	" 17, '92	♂	205	.....	120	29.6	14
1705	.....	" "	" 17, '92	♂	208	.....	125	30	14
1427	1239	Wareham, Plymouth Co., Mass.	May 28, '92	♂	.....	88	128	29	10 †
1944	1718	" "	July 13, '92	♀	.....	65	123.5	28	10.5
1945	1719	" "	Aug. 18, '92	♂	.....	89	131	29.5	8.5
1946	1720	" "	July 7, '92	♂	.....	86	148	29.5	12.5
1947	1721	" "	" 13, '92	♂	.....	63.5	117	27	10
1948	1722	" "	Aug. 12, '92	♂	.....	83	137	30.5	14

* Collected by H. H. McAdam. † Collected by Outram Bangs.

Cranial Measurements of Six Specimens of Zapus insignis.

Number	387 464	1*	1194 1378	1195 1379	1452 1656	1469 1674
Sex	♀	♂	♂	♂	♂	♀
Basilar length	18.5	19	19	19.8	20	19 8
Basilar length of Hensel	16.8	16.8	17.4	17.8	17.8	17.4
Zygomatic breadth	12.4	12.2	12.8	13	13	12.8
Mastoid breadth	10.2	10.3	10.6	11	11	10.6
Interorbital constriction	4.8	5	5	5	5	5
Greatest length of nasals	9.2	9	9.8	10	10.6	9.4
Incisor to molar	6	6.5	6	6	6.4	6
Incisor to post-palatal notch	8.8	8.8	9	9	9	9
Foramen magnum to post-palatal notch	7.8	7.8	8.4	8.8	8.8	8.6
Upper molar series along crowns.	3.7	3.7	4	4	3.8	3.8
Basioccipital to middle of parietal	7.6	8.5	7.4	7.8	7.4	8
Fronto-palatal depth at middle of molar series	12	6	6	6	6.4	6.2
Greatest length of mandible	12	11.8	12	12.4	12.8	12.2
Lower molar series along crowns.	4	4	4	4	4	4

*Collection of E. A. and O. Bangs.

Cranial Measurements of Six Specimens of Zapus hudsonius.

Number	519 585	540 623	541 624	542 625	543 626	547 631
Sex	♀	♀	♀	♀	♀	♂
Basilar length	18.2	18.2	17.4	17	17	17
Basilar length of Hensel	16.2	16.4	15.4	15	16.2	15.8
Zygomatic breadth	11.2	11.8	11.2	10.8	11	11 2
Mastoid breadth	10	10	10	9.8	10	10
Interorbital constriction	4	4.2	4	4.2	4.2	4.4
Greatest length of nasals	8.6	9 2	8.6	8.2	8.6	8.6
Incisor to molar	6	5.4	6	5.2	6	5.2
Incisor to post-palatal notch	8.4	8.2	8.4	7.8	8.2	8
Foramen magnum to post-palatal notch	7.4	8.2	7.4	8	8	8
Upper molar series along crowns.	3	3.2	3	3	3	3
Basioccipital to middle of parietal	8.2	8	8	8.2	7.4	8
Fronto-parietal depth at middle of molar series	5.6	5.8	6	5.8	6	5.8
Greatest length of mandible	11.4	11.8	11	11.4	11	10.4
Length of lower molar series along crowns	3.4	3.2	3.2	3.4	3.2	3.4

VOL. VIII, PP. 9-40, PLS. I-VIII JUNE 3, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

PALEONTOLOGY OF THE CRETACEOUS FORMATIONS OF TEXAS—THE INVERTEBRATE PALEONTOLOGY OF THE TRINITY DIVISION.*

BY ROBERT T. HILL.†

CONTENTS.

Page.

I. Stratigraphic Divisions and Nomenclature of the Comanche Series..... 9
II. Position and Characteristics of the Trinity Division..... 12
III. Fossils of the Trinity Division..... 15
IV. Age and Significance of the Trinity Division..... 17
V. Description of Species..... 20
VI. Plates..... 40

I.—STRATIGRAPHIC DIVISIONS AND NOMENCLATURE OF THE COMANCHE SERIES.

It has heretofore been impossible to present faunal studies of the paleontology of the various horizons of the Comanche Series,

* Presented at a meeting of the Biological Society of Washington, held January 28, 1893, and published by permission of the Director of the United States Geological Survey.

†The writer desires to express his indebtedness to the many friends whose advice has assisted him in the preparation of this paper: to Messrs. T. W. Stanton, W. H. Dall, Alpheus Hyatt, and F. H. Knowlton, of the United States Geological Survey, for aid in the determination of doubtful genera, and to Mr. J. L. Ridgway, artist, and Mr. C. W. Eddy, of Ware, Massachusetts, photo-engraver.

owing to the fact that the fundamental problems concerning the sequence and relative importance of its subdivisions had not been presented until lately, although the identity of the series, as a whole, was made known in 1886. Prior to that time most of its fossils had been described by Shumard, Roemer, and others, but it was supposed that the species all came from beds which were in some manner equivalents of the upper Cretaceous or the well known Meek and Hayden section. Since the writer ascertained that the Comanche Series was a distinct and lower Cretaceous formation he has spent several years in studying the subdivisions and their extent, in ascertaining the stratigraphic position of the fossils or faunas already described, and in arriving at a rational system of nomenclature.* These steps were necessary before the homotaxy of the series could be discussed.

In early papers by the writer,† pending more minute study of details, the Comanche Series was broadly divided into two divisions or convenient groups of strata, as follows:

(1) An Upper or Washita Division, so named because of its prevalent occurrence in the vicinity of Old Fort Washita, Indian Territory, whence some of the species, which I ascertained were peculiar to this division, were originally described by Professor Jules Marcou and the brothers Shumard. (2) A Lower, or Fredericksburg Division,‡ so named because many of its characteristic species were those described originally from the vicinity of Fredericksburg, Texas, by Dr. Ferdinand Roemer.§

In 1887, while studying the Cretaceous formations of Arkansas, the writer discovered that the beds of the Fredericksburg Division, so called, consisted of two well-defined groups of strata

---

* The Comanche Series of the Arkansas-Texas Region, by Robt. T. Hill: Bull. Geol. Soc. of America, vol. II, pp. 503-528.

† The Topography and Geology of the Cross-Timbers and Surrounding Regions in Northern Texas: Am. Journ. Sci., vol. XXXII, April, 1887.

‡ It has been alleged (Third Annual Report Texas Geological Survey, p. 272, and American Geologist, January, 1893), that the term Fredericksburg Division was originated by Dr. Ferd. Roemer. Inasmuch as Dr. Roemer never recognized the existence of the Comanche Series, it is impossible to suppose that he named its divisions, and from none of his writings can such an inference be made.

§ The evolution of knowledge concerning the Cretaceous formations of Texas prior to the writer's publications is set forth in Bulletin 45 of the U. S. Geological Survey.

entirely distinct from each other in paleontologic characters, and that it could be appropriately made into two divisions. For the upper of these, which is composed of the Caprina limestone and the "Comanche Peak Group" of Shumard in part, the name Fredericksburg was retained, and to the lower the name Trinity Division was given, thus dividing the Comanche Series, more in accord with its natural grouping, into three great divisions, instead of two, as originally proposed.

Since the publication of his Arkansas report* the writer has devoted several years to the study of the Trinity Division in Texas and Indian Territory, and has more fully differentiated its beds from those of the overlying Fredericksburg Division, and, furthermore, ascertained that it constitutes a paleontologic and stratigraphic division of the utmost importance in the interpretation of the North American Cretaceous.

In the same report upon the Arkansas Cretaceous a preliminary description of the Trinity Division was made, separating it into a lower or arenaceous terrane, and an upper or calcareous terrane, for which, in a final paper† upon the stratigraphic subdivisions of the Comanche Series, read before the Geological Society of America at its Washington meeting, December, 1890, the names of the Trinity sands and Glen Rose beds were respectively proposed and the following general arrangement of the series given:

C. The Washita or Indian Territory Division.
   10. The Denison beds.
   9. The Fort Worth limestone.
   8. The Duck Creek chalk.
   7. The Kiamitia clays or *Schloenbachia* beds.

B. The Fredericksburg or Comanche Peak Division.
   6. The *Caprina* and Goodland limestone.
   5. The Comanche Peak chalk.
   4. The *Gryphæa* rock and Walnut clays.
   3. The Paluxy sands.

A. The Trinity Division.
   2. The Glen Rose, or alternating, beds.
   1. The Trinity, or basal, sands.

* The Neozoic Geology of Southwestern Arkansas, vol. II of the Annual Report, Geological Survey of Arkansas, 1888.

† Loc. cit.

II.—POSITION AND CHARACTERISTICS OF THE TRINITY DIVISION.

Fuller details concerning the extent and occurrence of the Trinity Division have been largely set forth during the past year in a publication by the writer,* and much of its stratigraphic details and some of the final maps as made by him and his assistants, Messrs. J. A. Taff, J. S. Stone, W. T. Davidson, and N. F. Drake, have been printed still later.†

The details of the formation can be appreciated by referring to the published descriptions of three typical sections, made at widely separated intervals, showing the increasing thickness of the beds to the southward.

The first of these, made by the writer while employed upon the work of the Arkansas State survey, is described in the report upon the Neozoic geology of southwestern Arkansas.‡

The second represents the beds as they occur in the vicinity of the Paluxy and Brazos rivers, in north central Texas, and was made by the writer and his assistants, Messrs. J. S. Stone and W. T. Davidson, and published in the report "On the Occurrence of Underground Water,"§ and later in the Third Annual Report of the Geological Survey of Texas.‖ In this region the beds of the Trinity Division attain an established thickness of about 475 feet.

The third and southernmost section was made along the banks of the Colorado river between Austin and the Paleozoic contact in Burnet county by the writer and his assistants, Messrs. J. A. Taff and N. F. Drake. The rocks of the Trinity Division attain unusual development in this region and are very satisfactorily exposed. A profile¶ illustrating this section is published in the

---

*"On the Occurrence of Artesian and Other Underground Waters in Texas, New Mexico, and Indian Territory West of the Ninety-seventh Meridian" (pp. 41–166 of "Final Reports of the Artesian and Underflow Investigation, etc., to the Secretary of Agriculture." 52d Congress, 1st Session, Ex. Doc. 41, part 3, Washington, D. C., May, 1892).

†Report on the Cretaceous Area North of the Colorado River, by J. A. Taff. Austin, Texas, September, 1892.

‡Op. cit., pp. 116–126.

§Op. cit., pp. 111–112.

‖Op. cit., pp. 307, 310, 311.

¶Loc. cit., pp. 90–91.

report upon the "Occurrence of Artesian Water," and much of the detail of the section given in the Third Annual Report of the Texas Geological Survey.* The thickness of the rocks of the Trinity Division in this region is about 500 feet. The beds have not been systematically studied in their extent south of the Colorado river.

From study of these sections it is concluded that the beds, as a whole, indicate a progressive and continuous series of sediments, representing subsidence from land through littoral to offshore conditions, followed by renewed shallowing at its close. It consists of sands and conglomerates at its base, and grades upward into magnesian and chalky limestones. No sharp lines of demarcation can be drawn between the sands and limestones, so imperceptibly do they merge into each other.

The Basement Beds or Trinity Sands proper.—These consist mostly of unconsolidated fine conglomerate and sands of the nature locally known as pack sands, and contain, besides logs of silicified wood, occasional masses of firm, lustrous lignite of depressed oval cross-section, like those found in the Potomac formation near Muirkirk, Maryland. Large bones of vertebrates have also occasionally been found, notably near Millsap, Texas, Travis Peak post-office, and at Gypsum Bluffs, Arkansas, which are supposed to be the remains of Dinosaurs. It was owing to the occurrence of these bones that in an early paper these sands were at first termed the Dinosaur sands by the writer.†

The Glen Rose Beds.—Indurated layers of impure calcareous and yellow material succeed the sands, and become more calcareous and magnesian toward the top of the sections, but without any defined breaks in the sedimentation. In the medial and upper portions of the sections the magnesian and limestone strata assume great thickness and purity, and are separated by alternations of laminated, calcareous, and magnesian clays, as beautifully shown in the bluffs of Mount Bonnel, on the Colorado river, northwest of Austin.‡

* Loc. cit., pp. 265–300; also First Annual Report of Texas Geological Survey for 1889, 1890, p. lxxxv.

† Am. Journ. Sci., vol. xxxiii, April, 1887, p. 298.

‡ Photographs of the scenery and structure of the Cretaceous formations of Texas, made by the writer for the Texas State Geological Survey, can be procured from the Committee on Photographs of the Geological Society of America.

Molluscan and other invertebrate remains appear coincident with the calcareous beds, accompanied in some instances by plant and vertebrate remains, as at the plant beds three miles west of Glen Rose, Somervell county, Texas.

Aggregations of Species in Great Beds.—In various parts of the Glen Rose beds there are strata composed of shells of one predominant species, while in other cases there is an agglutination of shell fragments of many species in masses similar to the recent formation on the coast of Florida known as Coquina.

Coquina Beds.—These usually appear at the base of the Glen Rose beds or at the first appearance of marine mollusks in the series. In Arkansas, owing to greater alteration through calcification, they consist of much more indurated limestone material than in Texas. The massive beds are composed almost exclusively of small shells of many species, and usually have a dark-yellow color upon weathering. They outcrop at many places along the old military road between Antoine and Ultima Thule. Shell beds are especially well developed near Travis Peak post-office, near the Colorado river, where the Coquina beds are pure white in color and the shell fragments more siliceous and comminuted than in Arkansas.

The Oyster Agglomerate.—Near the base of the Travis Peak section is a stratum some four feet in thickness, composed exclusively of a fossil *Ostrea*, so poorly preserved that the specific nature cannot be ascertained, but which resembles *O. franklini* Coquand. A similar bed of *Ostrea franklini* occurs in the west bluff of the Little Missouri, three miles west of Murfreesboro, Arkansas.

The Vicarya Beds.—At Post Mountain, west of the town of Burnet, there is the remnant of a vast bed of agglomerate, composed entirely of the shells herein described as *Vicarya lujani* de Verneuil, cemented by a hydrocarbon matrix, probably grahamite. This bed is some ten feet in thickness, and is evidently near the base of the Glen Rose beds.

The Orbitulites Chalk.—Near the base of the Bluffs of the Colorado, about the middle of the Glen Rose beds (Upper subdivision) is a stratum of ten feet or more in thickness, composed entirely of a massive white chalk, studded with the minute shells of the foraminifera *Patellina* (*Orbitulites*) *texana* Roemer. This chalk extends southward into Hays, Comal, and adjacent counties.

The Requienia ("*Caprotina*") *Limestone.*—At Granbury and in southwestern Parker county there is a vast agglomerate composed entirely of the shells and casts of *Requienia texana* Roemer, to which Dr. B. F. Shumard gave the name "Caprotina limestone." This occurs well up in the Glen Rose beds, about one hundred feet from their top. There is a similar bed in the ravine near the east foot of Mount Bonnel, west of Austin. As shown by the writer,* there is another horizon of Caprotina limestone higher in the Comanche Series.

The Nerinæa Flags.—The summit of the Glen Rose beds, as seen in Mount Bonnel, consists of alternations of dimension layers of firm crystalline limestone and pseudo-oolitic marls. Some of these dimension layers in the peak of Mount Bonnel are composed almost exclusively of calcified forms of *Nerinæas.*

III.—FOSSILS OF THE TRINITY DIVISION.

The beds contain many plant, vertebrate, and invertebrate remains, which occur either separately or in association, as at one locality in the bed and banks of Paluxy creek, three miles west of Glen Rose, Texas. The more sandy basement beds, or Trinity sands, are, as a rule, deficient in organic remains, with the exception of silicified wood and lignite, although occasional vertebrates and invertebrates are found.

The lower beds of the Glen Rose subdivision abound in invertebrate remains, most of which, however, are but badly preserved casts. The Glen Rose beds also contain occasional plants and vertebrates, especially in their lower portion, where they grade into the underlying sands.

The upper beds of the Glen Rose Division are less abundant in fossil remains, and these are very poorly preserved as casts. The plants of the basement Glen Rose beds have been collected by Professor Lester F. Ward, of the United States Geological Survey, and studied by Professor W. M. Fontaine, of the University of Virginia. They are now in course of publication in the Proceedings of the United States National Museum.† The small but interesting collections of vertebrate remains, with the exception of a lepidotoid fish in the hands of Professor Cope,

* First Annual Report of the Geological Survey of Texas, 1889, Austin, 1890, p. 133.

† Proc. U. S. Nat. Mus., vol. xv, pp. —, pls. xxxv–lxiii.

have not been studied. In this paper will be presented a preliminary study of its invertebrate fauna.

The following is a list of the fossils collected or observed by the writer from all the beds of the Trinity Division in Arkansas and Texas:

Foraminifera:

Patellina texana (Roemer).

Echinodermata:

Epiaster (?) sp. indet.

Vermes:

Serpula paluxiensis sp. nov.

Molluscoidea:

Genus indeterminate.

Mollusca:

Anomia texana sp. nov.
Ostrea franklini Coquand.
Ostrea franklini ragsdalei var. nov
Pecten stantoni sp. nov.
Modiola branneri sp. nov.
Leda harveyi sp. nov.
Cucullæa gratiota Hill.
Cucullæa comanchensis sp. nov.
Cucullæa terminalis Conrad.
Barbatia parva-missouriensis Hill.
Trigonia stolleyi sp. nov.
Trigonia crenulata Roemer.
Chione (?) *decepta* sp. nov.
Eriphyla pikensis Hill.
Requienia texana (?) (Roemer).
Monopleura marcida White.
M. pinguiscula White.
Corbicula arkansaensis Hill.
Cardium (?) *sevierense* Hill.
Protocardia sp. indet.
Pholadomya knowltoni sp. nov.
Pholadomya lerchi sp. nov.
Pleuromya (?) *henselli* sp. nov.
Isocardia (?) *medialis* Conrad.
Natica (?) *texana* Conrad.

Viviparus natica (?) *cossatotensis* Hill.
Cylindrites (?) sp. indet.
Buccinopsis (?) *parryi* Conrad.
Tylostoma pedernalis (Roemer).
Vicarya branneri sp. nov.
Neritina austinensis Roemer.
Neritina sp. indet.
Neumayria walcotti Hill.
Acanthoceras (?) *justinæ* sp. nov.

Arthropoda:

Cypridea texana sp. nov.

Vertebrata:

Lepidotus.
Crocodila.
Dinosauria.
Chelonia.

Plantæ:

Many species, now in course of publication by Professors Ward and Fontaine, together with undetermined species resembling *Araucarites*, figured on plate 1.

IV.—AGE AND SIGNIFICANCE OF THE TRINITY DIVISION.

With the exception of the genera *Requienia* and *Monopleura*, the above list contains none of the hitherto familiar types of fossils found in the overlying Fredericksburg and Washita Divisions, such as the characteristic *Echinodermata*, *Radiolites* (alleged *Hippurites*), *Gryphæas* of the *Pitcheri* group, *Exogyras*, or *Schloenbachiate Ammonitidæ*, but possesses a molluscan fauna peculiarly its own, so far as America is concerned, which, accompanied by a well-preserved flora and vertebrate fauna, affords the first satisfactory and complete data for an age classification of the subdivisions of the North American Lower Cretaceous formation, and will enable us to more thoroughly interpret the succeeding divisions. This association of vertebrates, plants, and marine mollusca is a most important fact in the correct determination of the age of these beds, and they all apparently agree in conclusions.

Concerning the interpretation of the foregoing fossils, the following facts may be stated: The plants, as determined by Pro-

fessors Ward and Fontaine, originally in the Potomac region,* were long since referred by them to the Wealden, before they were known to occur in the magnificent Texas stratigraphic series.

The vertebrates have never been systematically studied nor collected, but the genera found all occur in the Lower Cretaceous of Europe.

Of the invertebrates the ostracoid crustacean *Cypridea* of the Glen Rose lower beds is, in Europe as in Texas, a prominent feature of the Wealden (Lower Neocomian) beds.

The foraminifer *Patellina* (*Orbitulites*) *texana* Roemer is indistinguishable from the *Orbitulites*, which characterizes the Upper Neocomian of France, and occurs there under lithologic conditions similar to those in Texas.

Of the Pelecypod mollusca proper the *Anomia* is indistinguishable from the *Anomias* of other ages.

The only Ostrea (*O. franklini* Coquand) seem identical with the figures of a form which has been described under many specific names from the Upper Jurassic, and Lower Cretaceous of Europe.

Pecten stantoni belongs to a group of the *Pectinidæ*, which has great specific development in the Neocomian of France, Spain, and Portugal.

Modiola, *Leda*, *Cucullæa*, *Protocardia*, *Corbicula*, *Pholadomya*, and the doubtful form called *Isocardia* have a wide range in the geologic column, but the forms found in the Trinity Division have a general varietal resemblance to those of the Neocomian.

The only well-defined species of *Trigonia* (*T. stolleyi* sp. nov.) belongs to the scabrate forms peculiar to the Cretaceous and later epochs. This is an important fact against the possible Jurassic age of the beds.

The aberrant genera, *Requienia* and *Monopleura*, which abound in the Glen Rose beds, are both characteristic Lower Cretaceous genera, occurring abundantly in Europe in the Neocomian beds and not ranging higher than the Cenomanian. In describing *Requienia* (*Caprotina*) *texana*, Roemer asserted that it was hardly distinguishable from the characteristic *Caprotina lonsdallii* of the Neocomian of France.

Of the Gastropoda, the genus *Ptycaria* is represented by *P. branneri* resembling a peculiar species of the European Neo-

* See various papers by Professors Lester F. Ward and W. M. Fontaine on the Potomac flora of the North Atlantic coast.

comian, *V. lujani* De Verneuil and which in every variation is identical with the figures of the European species.

Natica (*Tylostoma*) *pedernalis* Roemer is characteristic of the Tylostomas of the Neocomian of France, Spain, and Portugal.

Of the *Nerinæas* in the Texas beds all have the archaic form of the Jurassic and lower Cretaceous (*Neocomian*) Nerinæas.

Only one echinoid is found in the Trinity Division, *Epiaster* (?), but this is of the older Cretaceous aspect of the European forms.

Of the *Ammonitidæ*, which in Europe are most relied upon for the classification of subdivisions of the Cretaceous, it may be said that the Comanche Series below the Washita Division is very deficient in these, only four species being known in America. Of two of these only three individual specimens have been found, while the European Neocomian abounds in many species and genera. Of the two genera with one species each found in the Trinity Division, it may be said that one of them, *Neumayria*, belongs to a genus which occurs in the Purbeckian, or uppermost Jurassic, and Wealden of Europe, and hence may be accepted as strong evidence that these beds are not of late Cretaceous age. The other species, *Acanthoceras* (?) *justinæ*, is too poorly preserved to be of criterional value.

While the writer has throughout placed the Trinity Division in the Cretaceous, he tried to defer final discussion of their age until opportunity should arrive for careful study of these fossils. Owing to constant labors in the field upon the more important stratigraphic problems, this opportunity did not arrive until now. At the time the Arkansas report* was written it was held that the Trinity beds might prove to be Jurassic, but the careful revision here presented tends to remove this doubt and enables us to assert their Cretaceous age with more assurance. Whatever doubt may have been inferred from any expressions in previous publications,† it may now be stated positively:

---

* Op. cit.

† Through two unfortunate lapses in the typography of his former papers the attempt has been made to show that the writer did not hold the Cretaceous age of the Trinity Division, notwithstanding his repeated publications to the contrary. One of these is caused by the typographic error on page 84 of the report "On the Occurrence of Underground Waters," etc., Washington, May, 1892, where the clause "which are assumed to be the base of the true Cretaceous" is made to modify the words "Walnut clays," instead of "these beds," *i. e.*, the Trinity. The other lapse was of a somewhat similar nature in the previous publication on The Comanche Series of the Texas-Arkansas Region.

1. That there is not a single invertebrate species in the Trinity Division of exclusive Jurassic age, which would justify placing the beds in that period.

2. The genera all occur in the Cretaceous formations of the rest of the world, and many of them, such as *Requienia* and *Monopleura*, occur only in the Cretaceous. Hence the beds are Cretaceous.

3. The beds of the Trinity Division are of lowest Cretaceous age, Neocomian, because the genera all occur in the Neocomian or lowest Cretaceous of other countries, and because they contain none of the characteristic upper or middle Cretaceous forms.

Finally it may be stated that from the above comparison of the life of the Trinity Division with the Cretaceous life of Europe it is evident that it shows not only a resemblance, but a remarkable homotaxial similarity with the Lower or Neocomian of that country, the lowest faunas resembling the Wealden or Lower Neocomian, and the Upper Glen Rose beds the Middle and Upper Neocomian, especially as developed in the region of the Jura and in Spain and Portugal.

V.—DESCRIPTIONS OF SPECIES.

Foraminiferæ.

Patellina texana (Roemer).

Plate I, Figs. 2 (copied after Roemer), 2*a*, 2*b*, 2*c*, 2*d*.

Orbitulites texana Roemer. Die Kreidebildungen von Texas, p. 86, plate x, figs. 7*a*, *b*, *c*, *d*.

"Shell minute, attaining one-eighth of an inch in diameter; orbiculate, shield-shape, convex above, obtusely conical; central eminence umboniform, ornamented with close, fine, concentric striæ, otherwise smooth; lower part flat, slightly concave, with irregular, radiating, granular rugæ, as if perforated by worms."—Roemer.

Roemer said: "This species certainly belongs to that group of Lamarck's genus *Orbitulites*, which D'Orbigny separated as a distinct genus *Orbitolina*." Careful microscopic study of the interior structure by the writer shows the granular structure illustrated in figs. 2*a*, 2*b*, and that it belongs to the genus *Patellina* of Williamson.

This important foraminifer was first found by Roemer on the upper branch of the Pedernalis, associated with *Tylostoma pedernalis*. I have found its true position to be in the medial portion of the Glen Rose beds, where, as on the Colorado near the mouth of Bull creek, it occurs in a massive chalk some ten feet thick. The "*Orbitolina*" beds are among the most characteristic and distinguishing features of the upper Neocomian of Europe, in the region of Jura, and in Dauphine, Portugal, and Spain. Their occurrence in a similar stratigraphic position in the Texas region is additional evidence of the Neocomian age of the Glen Rose beds. This Texas form has also been reported by Karsten from the Neocomian beds of Venezuela.

Echinodermata.

Epiaster (?) sp. indet.

Only one echinoid has come under the writer's observation from the Glen Rose beds. It occurs about midway in the section, near Bull creek, Travis county, and in Somervell county, Texas. This has been submitted to Professor W. B. Clark, of Johns Hopkins University, who writes as follows concerning it: "I am inclined to think it not only a new species, but a new genus." The specimens are left in Professor Clark's hands for future determination.

Vermes.

Serpula paluxiensis sp. nov.

Plate I, Figs. 4, 4*a*, 4*b*.

Cylindrical tubicolate, marked by concentric lines of growth; occurs in colonies, radiating out from a central nucleus. Individuals several inches long, but it is impossible to trace complete length of specimens, owing to mode of growth. Adult specimens average one-eighth inch in diameter.

This is one of the most abundant forms in the basement horizon of the Glen Rose beds, and occurs attached to lignite, shells of *Ostreidæ*, and casts of other mollusks, or in immense colonies or spherical masses, some of which in Paluxy creek, averaging three feet in diameter, are composed entirely of this species.

The *Serpulas* have such wide geologic range and so few specific characters that they are of little value in geologic diagnosis.

Occurs at gypsum bluffs of the Little Missouri, and in great abundance at the plant bed near Glen Rose, and also throughout the extent of the lower fossiliferous Glen Rose beds in Texas.

Molluscoidea.

Genus indeterminate.

Microscopic oval cells about one millimeter in length, growing in colonies attached to shell of *Serpula paluxiensis* and other forms; cells not overlapping, but in close contact with each other, forming a single layer of delicate net-work.

The cells of this species have not the pyriform shape or imbricated arrangement of *Membranipora* or the vibracular cells of *Lunulites*, and hence are assigned to no generic position at present. This form is the only one belonging to this order yet found in these beds. It occurs attached to other shells in the beds of the plant locality on the Paluxy near Glen Rose, Texas, at the base of the Glen Rose beds.

Mollusca.

Anomia texana sp. nov.

Plate I, Fig. 5.

Anomia sp. indet. Hill. Arkansas Geological Survey, Annual Report 1888, vol. II, p. 135.

Thin, discoidal, indistinguishable specifically from many species of this genus; right or lower valve attached, concentrically laminated; left upper valve arched and very irregular; seldom exceeds one-half inch in greatest diameter.

This species abounds in the earliest fossiliferous horizon of the Trinity Division, such as the beds in Paluxy creek, west of Glen Rose, and at the gypsum bluffs of the Little Missouri, in Pike county, Arkansas. It also occurs in most of the localities throughout the extent of the Glen Rose beds.

Ostrea franklini Coquand.

Monographie du Genre Ostrea, p. 58, plate xxiii, figs. 8–10. Hill, Arkansas Geological Survey, Annual Report 1888, vol. II, plate v, figs. 1–18*a;* plate vi, figs. 19–25; plate vii, figs. 28–30.

The general aspects and variation of this characteristic oyster of the Trinity Division have been fully described and figured in my Arkansas report. Professor Marcou in a review of this work* has divided the form into many species, but the writer, from his extensive study of the occurrence of the specimens *in situ*, still believes in the unity of the species, although in Europe it has doubtless been the custom of earlier paleontologists to make many species out of variations.

Choffat† figures and describes from Portugal *O. harrosei*, a form which resembles a variety of *O. franklini* found at Glen Rose.

This species occurs in great abundance throughout the Trinity Division, especially at the plant beds near Glen Rose, at the base of the Glen Rose beds in the Colorado section, and in a similar horizon throughout the Glen Rose beds in Arkansas and in Texas.

It is interesting to note that none of the true *Gryphæas* or *Exogyras* have yet been found in the Trinity Division.

Ostrea franklini ragsdalei var. nov.

Plate I, Fig. 6.

Shell acuminate, oblong, marked by numerous, regular longitudinal costæ; beak of large valve prolonged, costate, sub-cylindrical.

Several incomplete specimens of the larger valve of this species were procured from the fauna at the plant bed near Glen Rose. The outline is somewhat similar to that of *O. franklini* Coquand, but the larger valve is much more round, the point more prolonged and characterized by the strong costæ which do not appear upon the adult specimens of the *O. franklini* elsewhere found.

* American Geologist, vol. IV, December, 1889, pp. 359, 360.

† Recueil de Monographies Stratigraphiques Sur le Système Crétacique du Portugal, par Paul Choffat. Lisbon, 1885, p. 37, plate iii, figs. 7, 8, 9, 10, 11, 12.

This variety is named for Mr. G. H. Ragsdale, the naturalist, of Gainesville, Texas.

Thus far this variety has only been found at Glen Rose.

Pecten stantoni sp. nov.

Plate II, Fig. 3, 3*a*.

Shell small, one and one-half inches in length, strongly eared, and ears rugose, the right one (not shown in figure) being marked by a deep fold. The surface of the larger valve is marked by strong, flattened, double ribs, each with a sinus its entire length, alternating with small single ribs, and by minute cross-lines. This marking distinguishes it from the *Vola*-like forms of the upper half of the Comanche Series. The smaller valve is not known.

This beautiful species occurs in the molluscan fauna at the plant bed on Paluxy creek, near Glen Rose; only three specimens have been found. Two of the specimens were very perfect, but were unfortunately lost in the removal of my collections from Cornell University.

This species is named for Mr. T. W. Stanton of the U. S. Geological Survey.

Modiola branneri sp. nov.

Plate V, Figs. 8, 9, 10.

Modiola sp. indet. Hill. Arkansas Geological Survey, Annual Report 1888, vol. II, p. 133, plate ii, figs. 18, 19.

Shell small, elongate, from one-half to one and three-quarters of an inch in length, elongated sub-triangulate, greatly thickened at umbonal region; umbones pronounced and rapidly narrowing to a rounded point; anterior portion somewhat flattened; posterior portion attenuated, thin, and strongly curving in outline; surface smooth, lustrous, marked by fine lines of concentric growth and faint radiating striæ.

This well-preserved little *Modiola* occurs sparingly in the lower Glen Rose beds at the gypsum bluffs of the Little Missouri, Arkansas, and in the plant bed near Glen Rose. It was originally figured, but not named, in my Arkansas report.

Leda (?) harveyi sp. nov.

Plate I, Figs. 7, 8.

Shell minute, one-sixteenth to one-eighth of an inch in length, elongate, smooth, concentrically striate; beaks situated at anterior third, blunt, thick, and recurving; posterior cardinal margin elongate, straight, or slightly concave; pallial margin straight or slightly sinuous; anterior cardinal margin short, straight; anterior margin very slightly rounded at base; posterior margin angular, short, and straight; anterior half of shell thick, subglobular; posterior half elongated, rapidly thinning posteriorly, and sometimes marked by a strong angular ridge extending from beak to union of pallial and posterior margin; cardinal area not exposed so as to show hinge mechanism.

This minute shell occurs in great masses, resembling small black specks in a calcareous cement, which under the magnifying glass reveals the outline shown in the figures; the hinge mechanism not seen.

Found thus far only at the plant beds of the Paluxy, near Glen Rose.

Named in honor of Mr. J. W. Harvey, who first collected from this locality, but died before the collections could be published.*

Cucullæa gratiota Hill.

Arca gratiota Hill. Arkansas Geological Survey, Annual Report 1888, vol. II, p. 133, plate 14, figs. 2, 2*a*. Described and figured in my Arkansas Report as *Arca gratiota*. Occurs also in plant beds near Glen Rose, Texas, and in bluffs of Colorado.

Cucullæa comanchensis sp. nov.

Plate III, Figs. 1, 2.

Cordate, globose, thicker and higher than long, subquadrate in lateral aspect; posterior margin strongly truncate, pallial margin gently rounded; anterior margin short and truncate; exterior of cardinal area elongate and broad; umbones small, high, and incurved, but not touching; shell thick, rough, and marked by strong, irregular, rugose lines; hinge mechanism not visible.

* See American Geologist, October, 1892.

This is one of the most characteristic species of the very base of the Glen Rose beds in Parker, Hood, and Comanche counties, and is the form which the writer once inferred to be analagous to *Imbonicardia cookii* Whitfield,* from the Raritan clays of New Jersey, which the fragments then found strongly resembled in outline and marking. The discovery of the specimen here figured, however, for the first time affords evidence for their satisfactory generic identification.

The specimen figured was found about three miles east of Millsap, Texas, at the contact of the Trinity sands and the calcareous Glen Rose beds. I have also found the species near Springtown, Parker county, and at Comanche, in the same horizon.

Cucullæa terminalis Conrad.

(See Report United States and Mexican Boundary Survey' Washington, 1857, vol. I, p. 148, plate iv, figs. 2*a* and *b*.)

Casts of this species are frequently met with in the Glen Rose beds. The shell has not yet been found.

Barbatia parva-missouriensis Hill.

This species, from Pike county, Arkansas, was described and figured in my Arkansas Report, p. 133, plate iv, figs. 4*a*, 4*b*, 5, and probably fig. 22, of plate ii, of same report.

Trigonia stolleyi sp. nov.

Plate III, Figs. 3 and 5.

Semi-lunate in general outline, beaks well forward and strongly recurved; anterior and pallial margin a strong continuous curve; posterior portion elongated with truncated posterior margin; cardinal area compressed. Surface marked by flexuous, noduled costæ, about twenty-two in number, narrow and high, separated by broad intercostal areas as in *T. alæformis* Lmk.; depressed cardinal area bordered on its outer side by a long narrow groove and marked by cross-ribs, flexing anteriorly.

This *Trigonia* differs from *T. emoryi* Conrad, of the Washita Division, in its general outline and entirely distinct surface mark-

*See Report of Arkansas State Geological Survey for 1888, vol. II, p. 126.

ing. (See U. S. and Mexican Boundary Report, vol. I, p. 148, plate iii, figs. 2*a*, *b*, *c*.) Occurs abundantly in the plant beds of the Paluxy. The species is named for Professor G. W. Stolley, of Austin, Texas, whose work as a collector is esteemed in both Europe and America.

Trigonia crenulata Roemer.

Plate III, Fig. 4.

Roemer. Kreidebildungen von Texas, p. 51, plate vii, fig. 6.

This species, described by Roemer from imperfect casts, may be the same as *T. stolleyi*. The specimen here figured was collected from the bluffs of the Colorado near Bull creek, Travis county.

Chione (?) **decepta** sp. nov.

Plate I, Figs. 9 and 10.

Shell sub-triangulate or elliptical in outline, compressed in cross-section from base to umbones; umbones forward of center, small, and touching each other; lunular area small, cordate oval; pallial margin widely rounding; anterior cardinal margin concave, shorter than posterior; posterior cardinal margin long, slightly convex, asymmetrical; cardinal mechanism not shown; surface marked by long concentric and very faint irregular lines, anterior muscular scar elongate, rounded; posterior muscular impression flat, depressed at extreme posterior end.

The casts of this form are abundant throughout the Glen Rose beds, but its generic position is uncertain. It may possibly belong to the *Cardiidæ*. In the hills north of Lampasas, near the top of the formation, the specimens occur in great abundance with the shell preserved in calcite, showing the exterior structure. Conrad's species of *Astarte texana*,* described from a cast from an unknown locality, has a superficial resemblance to this form, according to his description and figures, but it is more triangular and otherwise different, as seen by comparison with his type in the National Museum.

* U. S. and Mexican Boundary Report, vol. I, p. 152, plate v, fig. 9.

Eriphyla pikensis Hill.

Plate IV, Figs. 4, 5, 6.

Corbicula pikensis Hill. Arkansas Geological Survey, Annual Report 1886, vol. II, p. 134, plate ii, figs. 13, 13*a*, 14, 15, 16, 17.

This form was originally figured by the writer under the generic name of *Corbicula*, and is very closely allied to the so-called *Cyrena astarteformis* Koch and Dunker, from the Wealden of Germany. Professor Marcou has referred it to the *Astartidæ*, but it is undoubtedly a species of the genus Eriphyla of the Astartidæ distinguished by the lateral teeth.

It occurs in great abundance in Pike county, Arkansas, and sparingly at the plant bed of the Paluxy, near Glen Rose, Texas.

Requienia texana (?) (Roemer).

Caprotina texana Roemer. Kreidebildungen von Texas, p. 80, plate v, figs. 2*a*, 2*b*.

A *Requienia*, provisionally referred to *R. texana* Roemer, is one of the prominent species of the Glen Rose beds and occurs in massive agglomerate some twenty feet in thickness at Glen Rose, Thorp Springs, Granbury, and in southern Parker county. In Roemer's description he asserts that it is indistinguishable from *Requienia lonsdalli* D'Orb., of the French Neocomian, except by its thicker shell. It is desirable to closely compare this form with *R. patagiata* White.* Dr. Roemer says that the latter species is entirely distinct, the larger valve of *R. texana* not being so elevated as in *R. patagiata*. In the abundant material collected by the writer this distinction does not always hold good, yet there is a general difference in appearance, especially in the larger size and more rounded character of the valves of the Glen Rose forms, which may make it a distinct species from either of these. The type forms of the *R. texana* Roemer and the *R. patagiata* White occur in the horizon which we at present accept as the Caprina limestone, while the *Requienias* of the agglomerate at Granbury and at the base of the Colorado section occur several hundred feet below them, and may prove a distinct species.

Requienia is the lowest occurring genus of the aberrant Cham-

* *Requienia patagiata* White. U. S. Geological Survey, Bulletin No. 4, p. 6, plate v, figs. 1-8.

idæ, with the exception of Diceras, a Jurassic form, and is abundant in the Neocomian formation of Spain, France, and Portugal.

Monopleura marcida and **M. pinguiscula** White.

Bulletin U. S. Geological Survey, No. 4, p. 8, plate 5, figs. 1–8.

Casts and moulds of *Monopleura* occur in great abundance in the Colorado section, especially at the base of Mount Bonnel, near the mouth of Bull creek. It is impossible to make a correct diagnosis of these, owing to the fact that the smaller valves, so abundant in the Caprina limestone, have not been found in the Glen Rose beds, but there is a general resemblance of the larger valves to the two species named.

The genus *Monopleura*, according to Zittel, has wide distribution in the Lower Cretaceous, occurring in the Neocomian of Provence and the Jura mountains, and seldom ranging higher. In America the genus culminates in the Caprina limestone and is not known later.

Corbicula arkansaensis Hill.

Arkansas Geological Survey, Annual Report 1888, vol. II, p. 133, plate ii, fig. 20; plate iv, figs. 3, 3*a*, 6.

This species was originally figured and described in my Arkansas report. It occurs in Pike county, Arkansas, near Murfreesboro, and at the gypsum bluffs of the Little Missouri. It is less abundant in the Texas beds.

Cardium (?) **sevierense** Hill.

Arkansas Geological Survey, Annual Report 1888, vol. II, p. 134, plate ii, figs. 21, 21*d*.

This form has only been found in Arkansas, at the locality from which it was described in my Arkansas report.

Protocardia sp. indet.

Small casts, three-quarters of an inch in length, globose; surface marking, very fine lines.

The Comanche species of the genus *Protocardia* need careful revision, and this form may be found to belong to some of the numerous species already described. This species is distinguished only by a smaller size than that of all the other forms described. It occurs sparsely in the beds near Glen Rose.

Pholadomya knowltoni sp. nov.

Plate II, Figs. 1, 2.

Choffat (Matériaux pour L'Étude Stratigraphique et Paléontologique de la Province D'Angola, Geneva, 1888, p. 84, plate v, figs. 1–3) describes under the name of *P. pleuromyæformis* a form indistinguishable from this species. His description, as follows, corresponds fully with our species:

"Equivalve, inequilateral; swollen below the beaks; anterior border rounded and completely closed; posterior border compressed at the extremity, which is slightly turned upward, truncated and slightly gaping; beaks small, elevated, strongly inflexed and in contact with each other; cardinal portion of anterior border sloping and its continuation strongly rounded; the posterior cardinal border straight, slightly elevated to its extremity; anterior face blunt, behind which a slight, faint groove extends from the beak to the pallial border. The surface of the shell is marked by irregular longitudinal plications."—Choffat.

This shell can in no way be distinguished from the excellent figures and descriptions given by Choffat of *Pholadomya pleuromyæformis*, from Dombey, on the west coast of Africa, where a fauna closely allied to the Comanche series occurs, but of course their identity cannot be positively established without comparison of specimens. The faint grooves from beak to pallial border are not brought out well in our figures.

The form first appears in America in the medial portion of the Glen Rose beds of the Colorado river section, near the mouth of Bull creek, and again appears in the supposed Caprina limestone at Austin, in the Fredericksburg Division.

Pholadomya lerchi sp. nov.

Plate IV, Fig. 3.

Outline subpyramidal in lateral aspect; length, three and one-half inches; height, two and one-half inches; greatest thickness, two inches; beak situated at anterior third, of medium proportions; anterior margin semicircular in outline from beak to pallial margin, into which it merges by a continuous curve; pallial margin a continuous curve with the anterior margin, and rapidly increasing in curvature posteriorward, terminating obtusely with the truncated posterior margin; posterior margin sharply truncate, about one inch in length; anterior umbonal margin very short, marked by a small depression immediately below the

umbone; posterior umbonal margin elongate, sloping posteriorly at an angle of about 30 degrees from the umbone; this margin is straight when viewed laterally, but bends strongly outward toward the gaping posterior margin, with which it unites by a gentle curve; surface marked by strongly rounded ribs and grooves, subconcentric, sinuous and uniting with each other at a common groove which is parallel with the anterior margin.

Only a single poorly preserved cast of a right valve of this species has been found, the anterior portion of which is not visible. It was collected in the heavy conglomerate which marks the base of the Comanche Series at its contact with the Carboniferous formation, on Sycamore creek, Burnet county, Texas, near the crossing of the Burnet and Travis Peak roads. The species is named for Dr. Otto Lerch, of the Louisiana State Geological Corps, who, as a Texan, has made valuable contributions to the knowledge of his State.

Pleuromya (?) **henselli** sp. nov.

Plate IV, Figs. 1, 2.

Shell elongate-elliptical; length, three and one-quarter inches; height, two inches; umbones anteriorly subcentral, round, and not prominent; anterior margin strongly rounded, continuing by curvature into the pallial margin; pallial margin elongate, slightly curved; posterior margin sub-truncate, slightly gaping; anterior umbonal margin sinuous, slightly gaping; posterior umbonal margin about one-third longer than anterior; interior and hinge mechanism not seen.

The generic position of this species is very doubtful; but, inasmuch as it is one of the most characteristic casts of the Glen Rose beds in the Colorado River section, it is important that it should be here figured. The species has a resemblance to *Thracia myæformis* White, but differs in some details.

Isocardia (?) **medialis** (Conrad).

Plate II, Figs. 4, 5; plate III, Fig. 6.

Cardium mediale Conrad, U. S. and Mexican Boundary Report, vol. I, p. 149, plate iv, figs. 4*a*, *b*.

Conrad described this form as follows:

"Cordate equilateral, ventricose; base profoundly and nearly regularly rounded; beaks prominent; posterior margin truncated, direct."

To this I would add:

Variable in shape; shell thick, concentrically striate; beaks inturned as in *Isocardia;* anterior muscular impression very prominent, angular on anterior side; posterior muscular impression faint, large in area, almost indistinguishable; posterior margin truncate in normal specimens. Surface marked by strong concentric rugose lines.

The generic position of this form is not satisfactory, because the hinge structure has not been found. It is clearly not a *Cyprina*, although sometimes similar forms are referred to that genus by paleontologists in Europe; neither is it a *Cardium* as described by Conrad.

This is one of the most numerous, conspicuous, and characteristic species of the Glen Rose beds; it occurs as shelless casts by the thousands throughout the vertical and geographic extent in Texas and Arkansas, beginning in the lowest fossiliferous horizon and extending to the top.

A few specimens were found about ten miles west of Glen Rose, upon which fragments of the thick calcified shell structure were preserved, showing it to have a concentrically striated surface and the anterior cardinal margin and beaks to be as in *Isocardia*, as shown on plate vii, fig. 1.

The form varies greatly in shape, owing to the compression and distortion it has undergone in the strata. One of the extreme variations from the normal is illustrated on plate ii, fig. 5.

Natica (?) **texana** Conrad.

U. S. and Mexican Boundary Survey, p. 157, plate xiii, figs. 1*a*, *b*.

This species is of rare occurrence in the beds at Glen Rose. It is not a *Natica*, but inasmuch as only casts are preserved its generic position cannot otherwise be stated.

Viviparus (**Natica** ?) **cossatotensis** Hill.

Arkansas Geological Survey, Annual Report 1888, vol. II, p. 130, plate iii, figs. 4, 4*a*, 5, 5*a*.

This form was originally described in my Arkansas Report from an isolated locality in Sevier county. Many consider it a *Natica*, but it is too imperfect to assert its generic position with certainty. The writer inclines to the belief that it is a fresh or brackish water form.

Cylindrites (?) sp. indet.

The writer has collected from the base of the Glen Rose beds in Parker county a few specimens of a small gasteropod very much resembling *Cylindrites bullatus* Lyc. and Mort. Unfortunately the specimens have been lost.

Buccinopsis (?) **parryi** Conrad.

Plate VI, Fig. 1.

U. S. and Mexican Boundary Report, p. 158, plate xiii, figs. 4*a*, *b*.

B. Conradi Hill. Arkansas Geological Survey, Annual Report 1888, vol. II, p. 130, plate iii, figs. 2, 2*a*.

Conrad describes this species as follows:

"Subpyriform; longitudinally undulated and ornamented with rugose, revolving lines, spire scalariform; aperture large and patulous." Conrad also says: "Under this name I have described a cast which cannot be referred to any known genus; it is certainly not a true Buccinopsis, nor can its generic character be determined because of poor preservation."

The writer has found casts of this form in great abundance in the lower fossiliferous horizons of the Glen Rose bed at gypsum bluffs of the Little Missouri, in Arkansas, and at Glen Rose. In some instances the casts show marks in the shape of depressions extending across the lower whorl and the sutures are very deep and distinct. The whorls and spire of a more perfect specimen, shown in plate vi, fig. 1, are six in number and very flat and angular at their upper edge. Whatever may be the true generic position of this form, it is a very useful stratigraphic aid to the student of the Glen Rose beds. The form is readily distinguishable from *Tylostoma pedernalis* Roemer by its greater number of whorls and entirely different outline of the aperture.

Tylostoma pedernalis (Roemer).

Plate VI, Fig. 2.

Natica pedernalis and *N. praygrandis* Roemer. Kreidebildungen von Texas, p. 43, plate iv, figs. 1*a*, *b*; plate iv, figs. 1*a*, *b*.

"Shell large, ovate; whorls flat, angular above; lowest or basal whorl three times as high as the spire; spire composed of three coils. Aperture, elongate ovate."—Roemer

Dr. Roemer described this large and abundant species of the Glen Rose beds from specimens collected on the Pedernalis river. He also described *Natica* (*Tylostoma*) *prægrandis*, which he asserted differed only by its larger size.

The species occurs in the greatest abundance throughout the extent of the Glen Rose beds in Arkansas, Texas, and Mexico, and is preserved only as casts, without shell structure. From observations of hundreds of individuals, I am of the opinion that the two species of Roemer are identical.

These forms are indistinguishable from many species described from the Neocomian of France and Spain, where the genus *Tylostoma* has its culmination, ranging, according to Zittel, from the Upper Jurassic. *Tylostoma similimum* Choffat, from Portugal, a characteristic Neocomian form, is quite closely related, if not identical with the Texas species. It also resembles *N. gigas* Bonn. of the Jurassac.

The specimen figured here is a large flattened individual, illustrated in order to show the size and variation in comparison with the typical forms figured by Roemer.

This form occurs throughout the Neocomian of Mexico, in Venezuela, Bogota, and on the central Pacific coast of South America, and is one of the distinguishing fossils of the Glen Rose beds.

Vicarya branneri sp. nov.

Plate V, Figs. 1–7.

Pleurocera strombiformis (Schlotheim) Hill. Neozoic Geology of Southwest Arkansas, p. 129, plate ii, figs. 1, 2, 3, 4, 5, 6, 7, 7*a*, 7*b*, 8, 9, 10, 11, 12, 12*a*; plate iii, figs. 6, 6*a*, 6*b*, 6*c*, copies of European figures.

Compare—

Vicarya helvetica Verneuil and De Lorière. Description des Fossiles du Néocomien Supérieur de Utrillas et ses Environs, p. 2, plate i, fig. 1.

Vicarya lujani Verneuil and De Lorière. Ibid., p. 5, plate i, fig. 3.

Vicarya strombiformis Verneuil and De Lorière. Ibid., p. 7, plate i, fig. 4.

Vicarya pradoi Verneuil and De Lorière. Ibid., p. 10, plate i, fig. 5.

Turritella helvetica Pictet and Renevier. Mater. pour la paléont. Suisse du ter. aptien, 1854.

Cassiope helvetica H. Coquand. Monogr. paléont. de l'ét. aptien de l'Espagne, 1866.

Cerithium lujani Verneuil. Bull. de la Soc. Géol. de France, 2e liv. Tome x, 1853.

Cerithium luxani Verneuil. Memoria geognostica de Castellon par Vilanora, 1859, plate iii, Fig. 7.

Cassiope verneuilli H. Coquand. Monogr. paléont. de l'ét. apt. de l'Espagne, 1866.

Murex strombiformis Schlotheim. 1820, Petrefact., p. 144.

Muricites strombiformis Schlotheim. Monographie der Norddeutschen Wealdenbildung, Dunker, 1846, p. 50, pl. x, fig. 18*a*, *b*.

This form is indistinguishable from the figures of *V. lujani* and *V. helvetica* of De Verneuil and De Lorière, but without comparison of type specimens their identity cannot be positively asserted. *V. lujani* is described as follows:

"Shell elongated, with thick test; spire regular, straight, or sometimes a little pupoid; ten or twelve turns of the spire. Each turn of the spire is marked by numerous sinuous cross-striæ, strongly bent inward upon the first anterior quarter of each spiral. The sutures are generally well defined." The whorls are also usually marked by two longitudinal elevated bands, one near each border, which in the apical whorls and adult specimens appear as plain elevated bands, or may be in the lower two-thirds of the shell nodular. They continue upon the buccal face or base of the shell as bands. "The lip always presents at the posterior or upper end a pronounced gutter. The outer lip has a deep, broad indentation corresponding with the termination of the basal suture line beneath the last carina or row of tubercules. The inner margin of the labial opening is thickly encrusted."—De Verneuil.

This is one of the most abundant, variable, and characteristic forms of the Trinity Division, occurring in the lowest molluscan horizons of the Glen Rose beds throughout its extent from Antoine, Arkansas, to the Colorado river in Texas. It was first figured from America by the writer in his report upon the Cretaceous beds of Arkansas under the name *Pleurocera strombiformis* Schloth., after Zittel. Although a very abundant form, the oral aperture was only recently discovered, it having hitherto been broken in the delicate structure of the specimens, and the generic position thereby made uncertain, as is attested by the widely different genera to which it has been referred in Europe.

The smallest and largest forms are void of the handsome rows of tubercules which distinguish the specimens of medium size. The larger adult specimens sometimes attain a length of two inches.

This form is of interest because it is the characteristic species of the Wealden (Lower Neocomian) beds of Europe. It may be the same as *Melania strombiformis*, first described from the Wealden strata of North Germany by Schlotheim.

De Verneuil and De Loriere, in 1886, published most excellent figures and descriptions in their paper upon Matèrieux pour le Paléontologie de l'Espagne, entitled "Description des Fossiles du Neocomien Superieur de Utrillas et ses Environs," Paris, 1868. They review the literature of the species and refer it to the *Vicarya*, a subgenus of *Cerithida*. They make four distinct species of their specimens, which I believe to be variations of the same species, all of which except one occur in intimate association in the lower Glen Rose beds.

Professor Jules Marcou, in the previously mentioned review of my Arkansas species, asserts that the form is a *Nerinæa*, but the forms are absolutely void of the characteristic folds which occur upon the columella of that genus, and hence he is mistaken.

The form occurs in great abundance at the gypsum bluffs of the Little Missouri, in Arkansas. At the plant bed locality near Glen Rose, Texas, it is still more abundant and shows the variety *helvetica* and *lujani* preserved together in great masses. At Post Mountain, near Burnet, Texas, the badly worn shells of this species occur in an agglomeration ten feet thick (plate v, fig. 7), void of other species and embedded in a matrix of the mineral grahamite. In this mass all the varieties can be found in association.

Nerinæa austinensis Roemer.

Roemer. Paleont. Abhandl., vol. iv, p. 295, plate 31, fig. 8.

Fragments resembling this species are abundant in the upper or Mount Bonnel beds of the Glen Rose beds, but are so poorly preserved as to render their assignment to it only provisional. I have found them in the Strontionite beds of the Colorado section, and a stratum of the beds near the summit of Mount Bonnel consists almost entirely of calcified *Nerineas*. In outer

marking they correspond to the *N. austinensis* of Roemer, originally collected from the Caprina limestone near Austin.

The *Nerineas* do not occur in the Comanche series higher than the Caprina limestone of the Fredericksburg Division and not at all in the Upper Cretaceous, where Roemer erroneously supposed this species (originally collected by Mr. Stolley) to occur.

Neritina sp. indet.

A characteristic fossil of the beds at the base of the Glen Rose subdivision is a small *Neritina*. Unfortunately the writer's specimens were lost in the removal of his collections to Washington, but there are others in the United States National Museum, which he collected from Hood county for the United States Geological Survey in 1886, and it is hoped that they will be figured and described.

This form occurs throughout the basement beds in Arkansas and in Hood and Parker counties, Texas.

Neumayria walcotti Hill.

Plate VIII, Figs. 1, 2, 3.

Ammonites walcotti Hill (not Sowerby). Annual Report Geological Survey of Arkansas 1888, vol. II, p. 139, plate I, figs. 1, 1*a*, 1*b*.

Nikitin (Mem. de l'Acad. St. Petersburg, 1881), defines this genus as follows:

> Shell flat, widely umbilicate; convolutions thinly rounded, marked by fine falcate lines; lobes and saddles low, slightly incised; siphonal lobes longer than the first laterals; the two lateral and accessory lobes little developed.

Only one specimen of this species has thus far been discovered. It occurred in association with *O. franklini*, *Vycaria lujani*, *Eriphyla arkansaensis*, and other mollusks herein described. The form very much resembles in outward appearance the figures of the genus *Oxynoticeras* of Hyatt, as given by Zittel and Steinman in their Manuals, but Professor Hyatt refers to it to *Neumayria*, and contributes the following comments upon the specimen:

"Your *Ammonites walcotti* is probably a *Neumayria*. The aspect is Jurassic, but this group, Upper Jura, and the species

nearest *walcotti* occurs in the very top of the Jura of Central Volga stage, supposed by some to be similar to the Purbeck in the upturn at Malm. The obscuration of a portion of the sutures occurs over the most important part of the outer side, and the structure of the abdomen, which is rounded and has no keel, is not very consistent with the reference either to the *Neumayria* of the Jura or the so-called *Neumayria* of the Cretaceous. Nevertheless it agrees better with those of the Jura than the Cretaceous ones referred to the same genus by Nikitin."

Whatever may be the range of this genus in Europe, the writer is inclined to the belief, from the stratigraphy and association, that its occurrence in Arkansas is lowest Cretaceous, and Professor Hyatt's opinion serves to strengthen the position of the writer in his reticence in earlier papers in expressing a more definite assignment of the Trinity beds before minutely studying the accompanying faunas. The specimen was collected in the banks of Town creek, one mile southeast of Murfreesboro, Arkansas. Named in honor of Mr. C. D. Walcott.

Acanthoceras (?) **jus inæ** sp. nov.

Plate VII, Figs. 1, 2, and 3.

Discoidal thin and flattened in general outline, deeply umbilicate, marked by numerous simple, gently sinuous ribs extending across the convolution and separated by shorter ribs, which disappear near the middle of the convolution; abdomen oblately rounded; suture lines not preserved in specimens found; umbilicus (fig. 2) narrow, depressed.

This species occurs in a coarse sand in the Trinity beds of Travis Peak post-office, in western Travis county, Texas, only four specimens having thus far been found. It is preserved as a cast, unpropitious for the preservation of the shell structure. It is the only ammonitic form thus far found in the Trinity Division, excepting *Neumayria walcotti*, but is of little value in determining the stratigraphic position of these beds.

Professor Hyatt has provisionally referred it to the family *Acanthoceratidæ*, and suggests a resemblance to *A. remondii* Gabb, from the Cretaceous of California. Our species, however, in the writer's opinion, is quite different in general aspect, being very much more flattened, more rectangular at the dorsum, and possessing wider convolutions. It has some external resemblance also to the genus *Hoplites*.

ARTHROPODA.

Cypridea texana sp. nov.

Plate I, Figs. *3a*, *3b*.

Shell microscopic; elongate ovate globose, with angular appendage shown in fig. 1: opalescent or horny; cardinal margin toothless, thickened centrally; opposite or ventral margin slightly undulate; surface smooth, and not visibly punctate.

It is difficult, says Zittel, to classify with certainty even the families of the Ostracoda, owing to the fact that the shell only is preserved, which is not sufficiently differentiated to justify exact diagnosis. The species here given occurs in abundance in the Glen Rose beds, but usually only the merest outlines are preserved, or mere granules which suggest the form. In the molluscan fauna at the plant bed of the Paluxy, near Glen Rose, however, I was so fortunate as to secure a small fragment in which the shell structure was well preserved. That the species belongs to the *Cyprida* is strongly probable, resembling both the genera *Cypris* and *Cypridea*. I have placed it in the latter provisionally, because it is a marine form, occurring in masses of marine shells or mollusca, while the former genus is a fresh water one and of more recent occurrence.

There are large masses of sub-oolitic material in the Mount Bonnel beds, which are apparently largely composed of these minute Crustacea. The *Cyprida* are also abundant in the Lower Neocomian, or Wealden, of Europe.

PLANTÆ.

Undetermined species.

Plate I, Figs. 1, *a*, *b*, *c*, *d*.

("Goniolina?" of author's previous writings.)

Spherical cone-like bodies, varying in size from three-quarters to one and one-half inches in diameter; slightly elongate, oblate or depressed at upper end, with well defined circular scar showing attachment to receptacle; surface consists of minute imbricate scales, usually worn down or indistinct; scales elongate ovate or sub-diamond-shaped, elongated toward upper end, and crowded around receptacular scar; seed minute.

This problematic organism has been provisionally referred to *Goniolina* in my previous papers. It occurs from the base to the top of the Glen Rose beds as small spherical calcareous casts, and extends into the lower layers of the Comanche Peak group at Mount Barker, Travis county. The biologic relations of this organism have been a problem for years, and it has been referred to the Echinodermata, the Foraminifera, and to the vegetable kingdom by various persons to whom it has been submitted. Its occurrence in the chalky strata of the Colorado section remote from other land débris and in association with Foraminifera (*Orbitulites texana* Roemer) seemed to oppose the fact that it was a fruit or a land plant. The recent discovery by Mr. J. W. Harvey of other plants of many species in the chalky limestone beds near Glen Rose, which have recently been described in the proceedings of the United States National Museum by Professor Fontaine, dispelled the foregoing hypothesis. Immediately beneath the stratum containing the plant bed is another containing many flattened moulds of what could be mistaken for fucoid stems, and associated with these are numerous specimens of the fossil here figured. A careful study *in situ* of the surface of a stratum in which these stems were well exposed showed that they branched very much like coniferous plants. At the termination of each ramification was found one of the small spherical casts, as if the limb of a plant laden with cones had been buried in the mud and its cast preserved. Recently, however, the fruit structure has been determined in the specimens themselves as figured on plate i.

The species should be named for Professor Lester F. Ward, who has done so much for American paleo-botany and has ever encouraged the writer in his studies.

The form occurs from Glen Rose southward to the Colorado in great quantities and ranges throughout the Colorado River section.

It could be doubtfully referred to the genus *Araucarites*, which it more closely resembles than any other, although this is for the botanists to determine. This genus is abundantly represented in the Wealden (Lower Neocomian) of Europe and in the Potomac formation of this country, as described by Professors Ward and Fontaine.

Plate I.

Figure 1.—An undetermined plant.

1*a*.—Imbricate scales of cone (?), enlarged.

1*b*.—Imbricate scales (worn) showing seeds (?).

1*c*.—Scars, apparently attachment of seeds.

1*d*.—Outlines of scales and seeds (?) on worn surface.

Figure 2.—Pattellina texana (Roemer). (Copy of Roemer's figure of Orbitulites texana.)

2*a*.—Cross-section, showing irregular structure of interior.

2*b*.—Portion of base, showing irregular granular structure.

2*c*.—Pores of upper surface, greatly magnified.

2*d*.—Labyrinthoid pores of another part of upper surface, magnified.

Figure 3.—Cypridea texana sp. nov.

3*a*.—Ordinary aspect of shell.

3*b*.—Ventral border of union of valves.

All magnified 100 times.

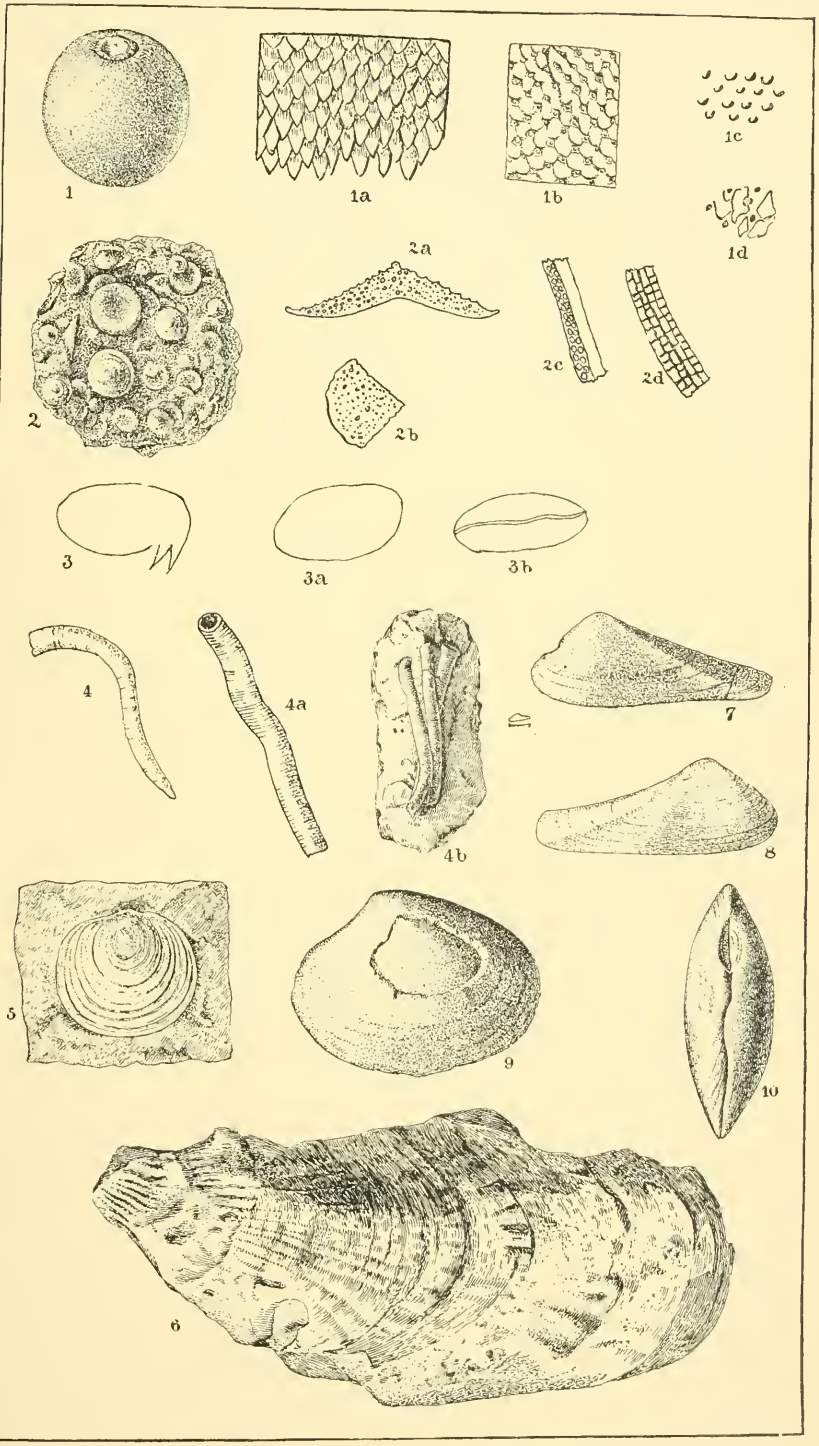
Figure 4, 4*a*, 4*b*.—Serpula paluxiensis sp. nov.

Figure 5.—Anomia texana sp. nov.

Figure 6.—Ostrea franklini ragsdalei var. nov.

Figures 7, 8.—Leda harveyi sp. nov. Magnified 20 diameters.

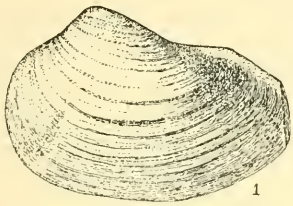
Figures 9, 10.—Chione (?) decepta sp. nov.



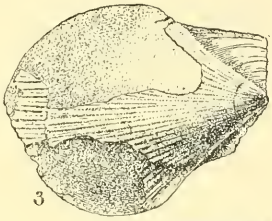
Invertebrates of the Trinity Division—Hill.

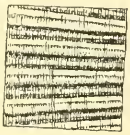
Plate II.

Figures 1, 2.—Pholadomya knowltoni sp. nov.
Figure 3.—Pecten stantoni sp. nov.
3*a*.—Detail of marking of larger valve.
Figure 4.—Isocardia (?) medialis (Conrad).
Figure 5.—Distorted specimen.

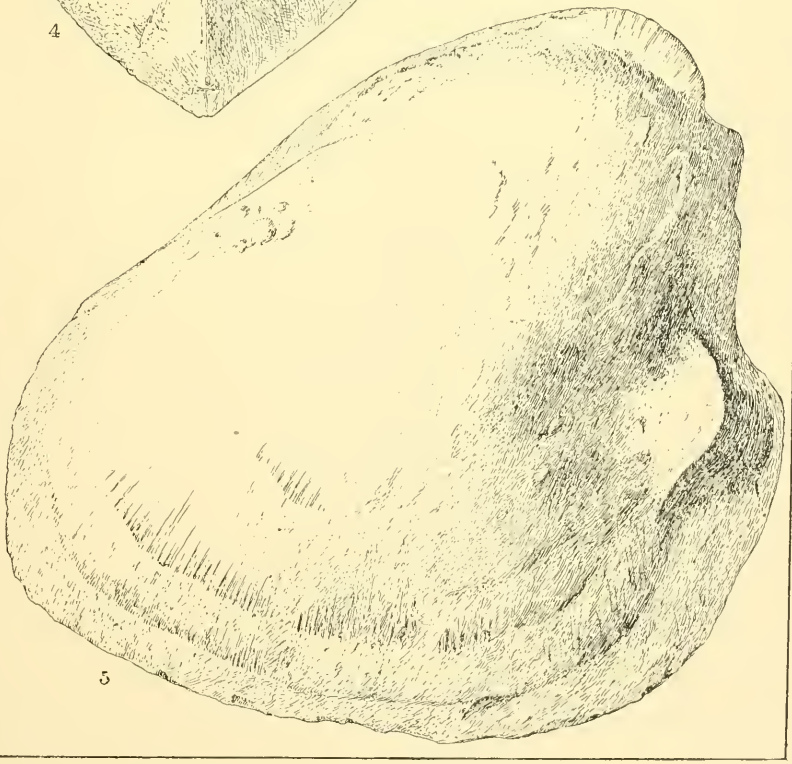

1

2


3


3a

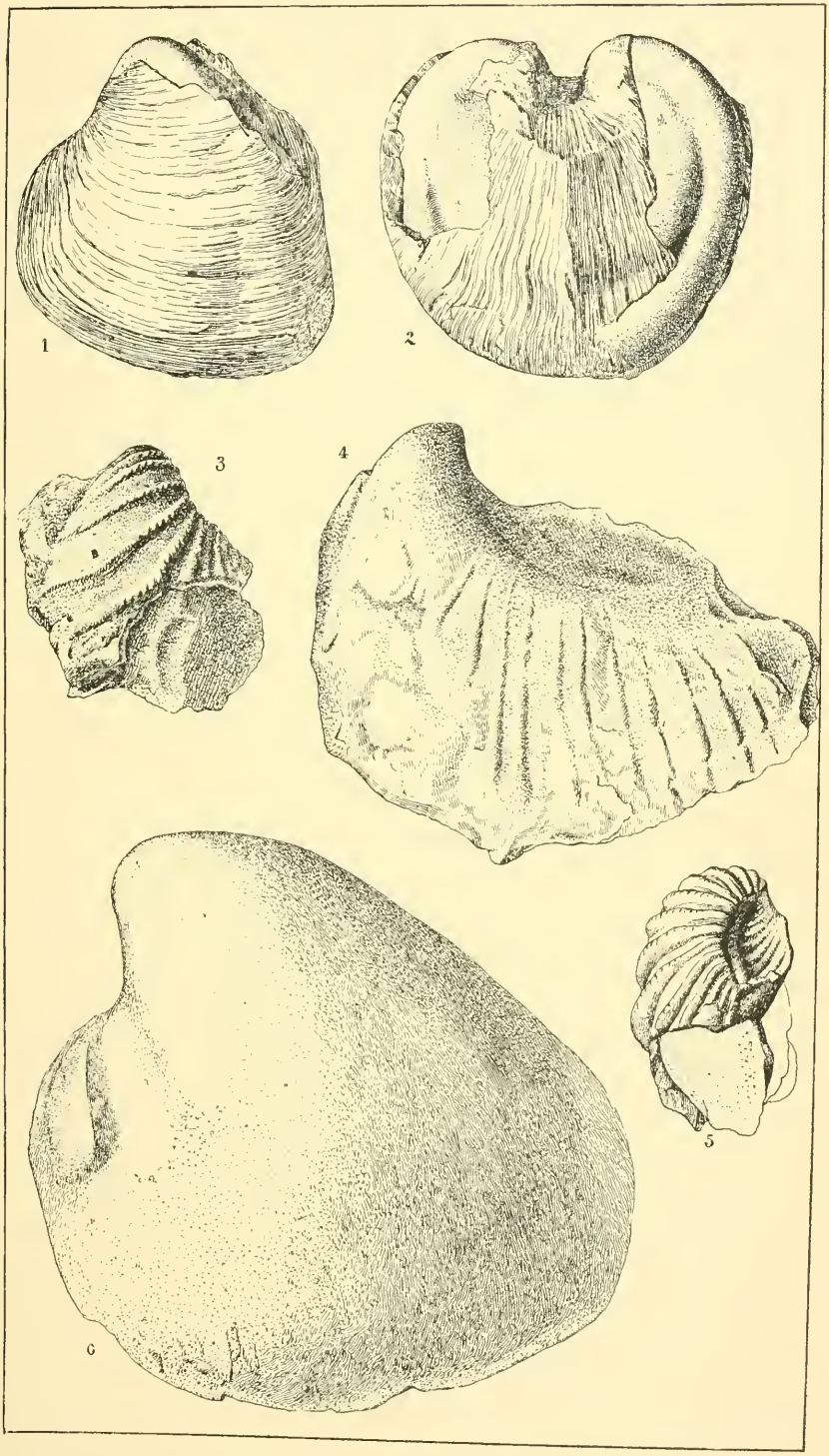
4


5

Invertebrates of the Trinity Division—Hill.

Plate III.

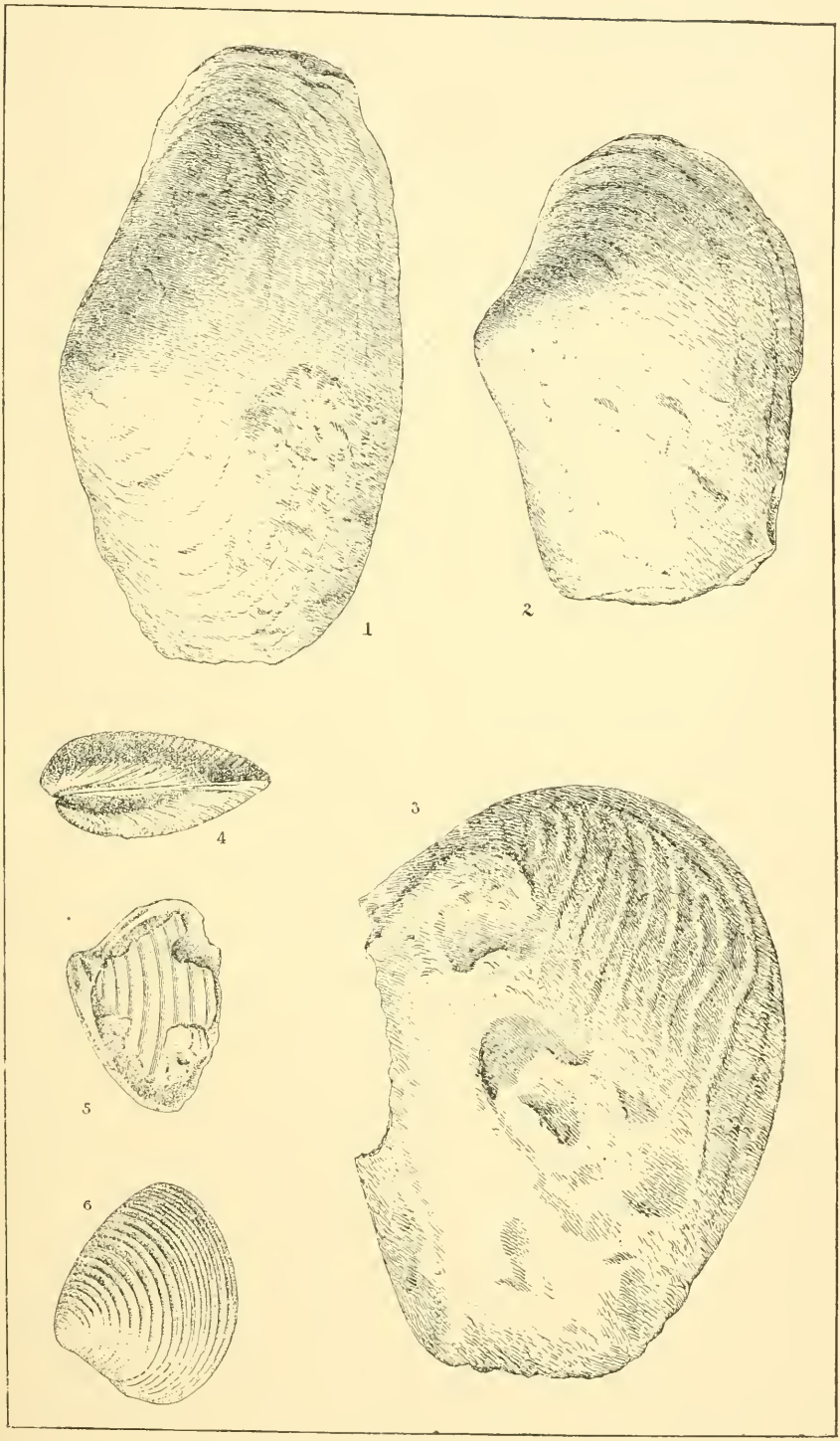
Figures 1, 2.—Cucullæa comanchensis sp. nov.
Figures 3, 5.—Trigonia stolleyi sp. nov.
Figure 4.—Trigonia crenulata Roemer.
Figure 6.—Isocardia (?) medialis (Conrad).



Invertebrates of the Trinity Division—Hill.

PLATE IV.

FIGURES 1, 2.—Pleuromya (?) henselli sp. nov.
FIGURE 3.—Pholadomya (?) lerchi sp. nov.
FIGURES 4–6.—Eriphyla pikensis Hill, magnified 2 diameters.



Invertebrates of the Trinity Division—Hill.

Plate V.

Figures 1–4.—Vicarya branneri sp. nov., showing marking of younger forms (V. lujani variety. Magnified 2 diameters).

Figures 5, 6.—Vicarya branneri (V. helvetica variety). Adult form, showing aperture.

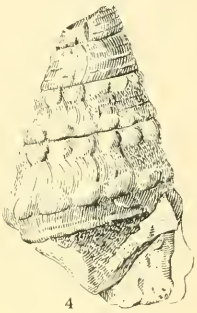
Figure 7.—Vicarya branneri. Mass, showing occurrence of species and variations.

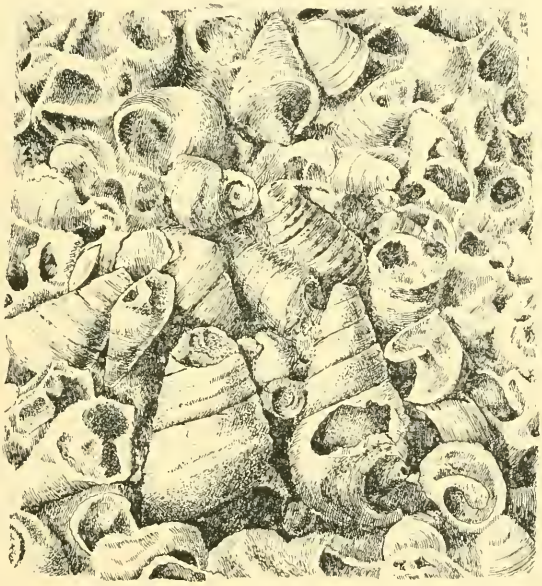
Figures 8–10.—Modiola branneri sp. nov. Magnified 2 diameters.

1

2

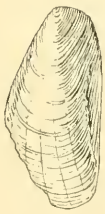
3


4

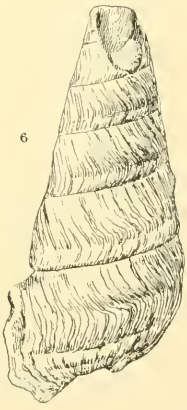

7

5

8


9

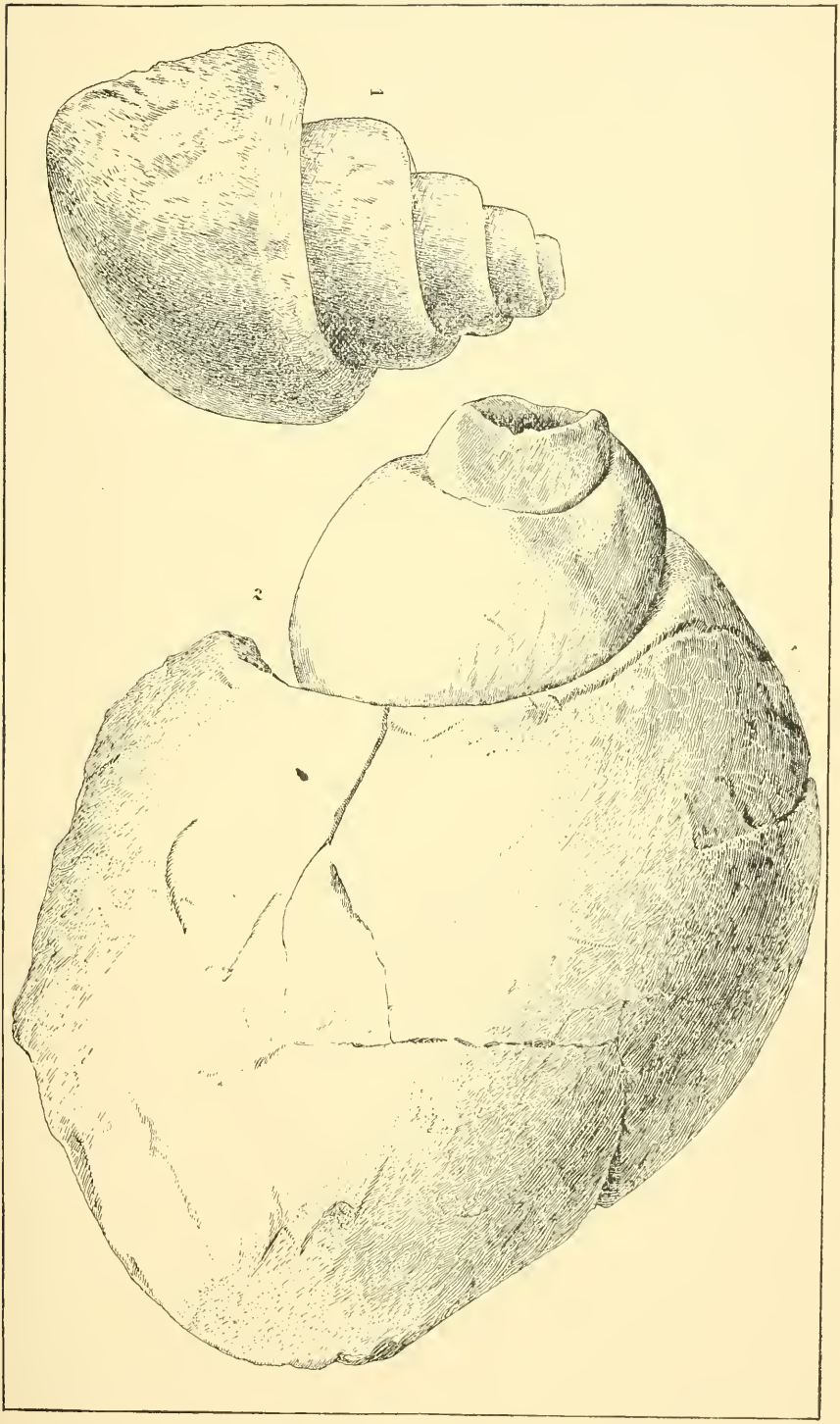
10


6

Invertebrates of the Trinity Division—Hill.

PLATE VI.

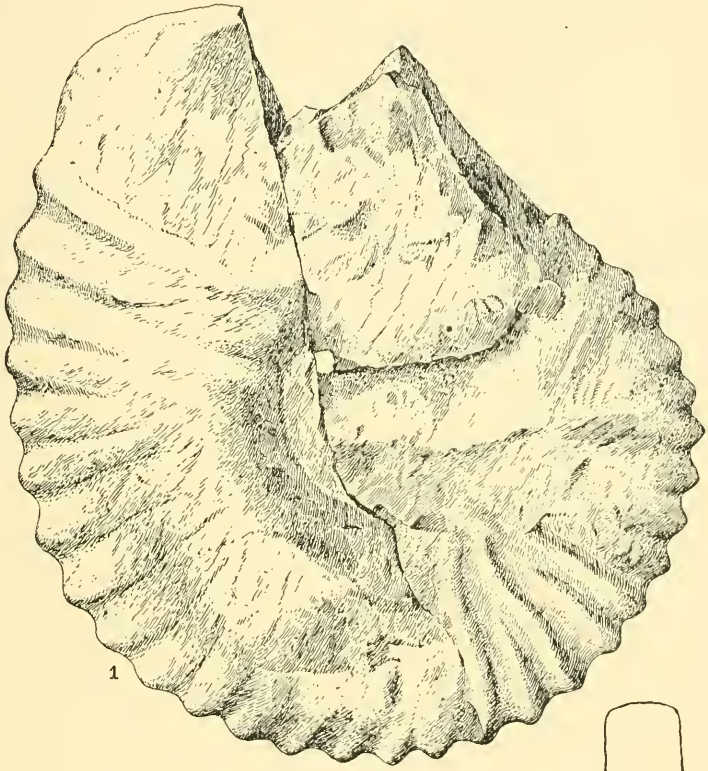
FIGURE 1.—Cast of Buccinopsis (?) parryi Conrad, showing spire.
FIGURE 2.—Tylostoma pedernalis (Roemer). Distorted specimen.

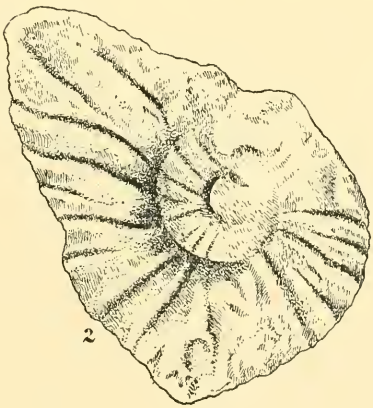


Invertebrates of the Trinity Division—Hill.

PLATE VII.

FIGURES 1 and 2.—Acanthoceras (?) justinæ sp. nov.

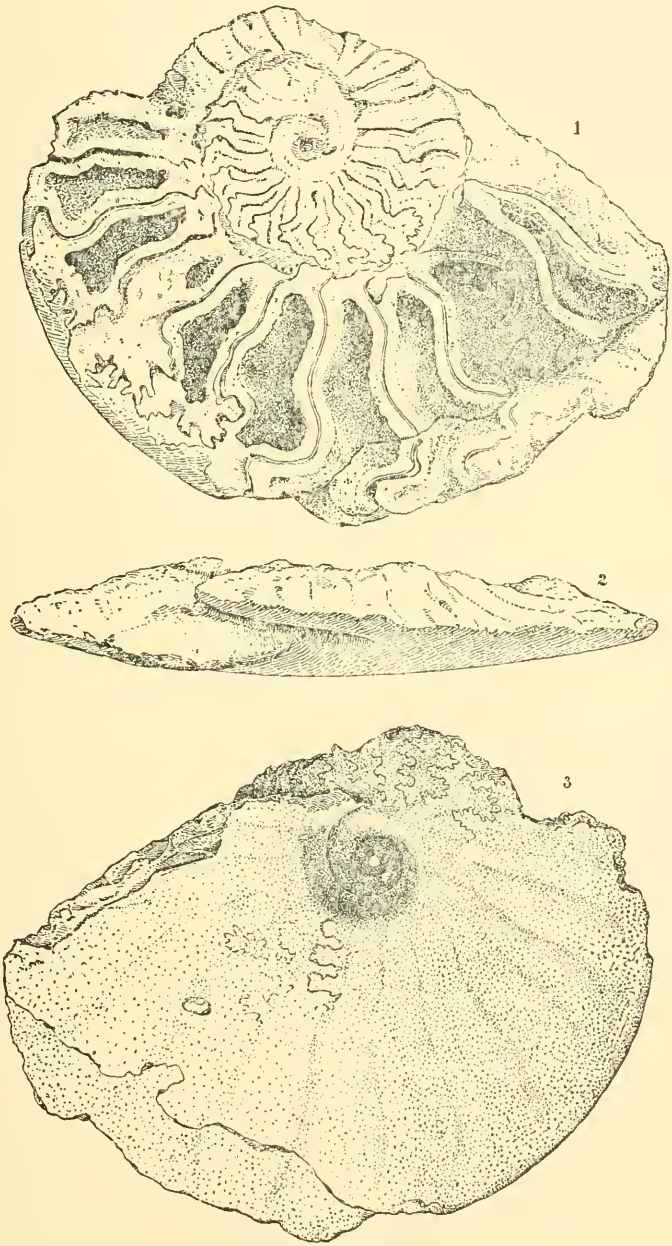




Invertebrates of the Trinity Division—Hill.

PLATE VIII.

FIGURES 1–3.—Neumayria walcotti Hill.



Invertebrates of the Trinity Division—Hill.

Vol. VIII, pp. 41-54, pl. IX June 20, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

FURTHER NOTES ON YUCCA INSECTS AND YUCCA POLLINATION.*

BY C. V. RILEY, PH. D.

Pronuba maculata.

Since the presentation, a year ago, of the communication on "Some Interrelations of Plants and Insects," in which I summarized what was then known of Yucca pollination and the Yucca moths, some further interesting observations have been made, and the facts which I have to present to-night should be looked upon as additional to those set forth in the previous paper (vol. VII, pp. 81–104). On account of the singular structure of *Yucca whipplei*, which was known to be pollinated by *Pronuba maculata*, I was quite anxious to obtain the facts in reference to this species. The long stamens, the sticky and abundant pollen, and the peltate stigma, with its long hyaline papillæ, are characters which would seem to facilitate ordinary pollination, though the restricted style would render this more difficult, and the peculiarities of *Pronuba maculata*, with its modified tongue, and maxillary tentacles very long and attenuated at tip, were, I felt quite sure, special adaptations to fit it for its work. This Yucca is not only one of the most interesting from the structure of its flower, but is one of the noblest of the

* Presented at a meeting of the Biological Society of Washington, May, 1893.

cespitose species and placed in the subgenus Hesperoyucca. The flowers are borne in immense panicles on a stalk which arises directly from a crown of leaves near the ground and reaches sometimes a height of twelve feet or more, and I present herewith a photograph which very well illustrates the magnificence of some of the larger specimens (pl. IX). At my request Mr. D. W. Coquillett, of Los Angeles, California, made some special observations last year on the pollination of this species, and on the 12th of June he was able to witness the operations both of oviposition and pollination on a plant while yet the sun was shining brightly, about forty minutes before setting. The act of oviposition does not differ in any particular from that which I have already described in detail for *Pronuba yuccasella*. The pollen is deliberately gathered, and a mass nearly half the size of the insect's head is held under her neck by the coiled tentacles. In pollinating, the tentacles are uncoiled and stretched so that the tips may be inserted into the upper part of the stigma. Mr. Coquillett describes the process of thus pollinating the stigma as lasting about half a minute, after which the insect that he watched descended the ovary and at once mounted to the top of one of the stamens. Here, with her tentacles, she removed both pollen masses (moving her head from side to side during the operation) and added the pollen thus gathered to the mass which she was already carrying. She went to two other stamens in succession, gathering a pollen mass from each. Mr. Coquillett, in communicating his observations, remarks that "it was indeed surprising to witness the evident intelligence which this insect displayed in all her actions wherever the pistil of the flower became pollinated solely through her own labors, and that she went through these maneuvers with the evident intention of pollinating the flower appears to admit of no doubt."

A number of insects have been observed associated with the flowers of *Yucca whipplei*, but none of them as observed by Mr. Coquillett acted in any way to produce pollination, either intentionally or by accident. As a check to prove the influence of Pronuba on the production of fruit, I desired Mr. Coquillett to enclose another panicle and exclude the moths. We were both somewhat surprised at the result, namely, that a certain number of the pods set on this panicle, and this would prove that (so far as a single experiment justifies conclusion) the species is capable of a certain amount of self-fertilization.

Yucca whipplei.

So far as they go, Mr. Coquillett's observations on the actions of *Pronuba maculata* agree very well with those of Professor William Trelease, who made a special trip through the southwest in the spring of 1892 with a view of studying the pollination of those Yuccas which had not hitherto been studied in this connection. He has published a most interesting article in the Fourth Annual Report of the Missouri Botanical Garden, entitled "Further Studies of Yuccas and their Pollination." This is, in fact, a most valuable contribution to our knowledge of the subject, and is complementary and additional to my own paper published in the annual report of the same series for the previous year. Mr. Trelease's life studies of *Y. whipplei* have added materially to our understanding of its floral characteristics. The anther cells on dehiscing contract so as to expose the pollen freely, but the contents of each cell forms a "rather consistent, two-lobed moist mass, which is held by its lower part but protrudes prominently from the open anther." The ovary is free from the longitudinal depressions which in the other Yuccas usually correspond with the appressed stamens. The capitate stigma is slightly indented at the center "and covered with long, hyaline, delicate papillæ which are always moist with abundant secretion that at length becomes almost gelatinous over the middle of the stigma." He found the nectar apparatus well developed, the septal glands, though narrow, reaching commonly to the base of the ovary, with a conducting groove of corresponding size. The glands are, also, though smaller, more active than in most other species of Yucca studied by him. Professor Trelease also notes that the characteristics of this flower would seem to make it easily self-fertilizable, and remarks on the exceptional occurrence in the lower part of the Cajon Pass of a few plants with more or less abundant, partly developed, but unusually diminutive capsules, in which no evidences of Pronuba action were to be found; and this, added to the experiment made by Mr. Coquillett, would seem to indicate that where Pronuba is absent *whipplei* has the same exceptionally limited power of fructification, whether by self-pollination or pollination by other agents, that we know to be possessed by *aloifolia* among the true Yuccas. Recognizing this possibility, Professor Trelease was somewhat surprised to find that, with the single exception which he noted, no fruit, among all his observations, was discovered which did not clearly show the work of Pronuba.

From his account, as well as that of Mr. Coquillett, it appears evident that *Pronuba maculata*, in accordance with the greater tendency of the flowers of *whipplei* to open during the day, is more diurnal in habit than *Pronuba yuccasella*, carrying on the acts of oviposition and pollination during the day. Further, unlike the other Pronubas so far known, this species rests with the head toward the stigma, and when disturbed is very apt to drop suddenly from the flower and take wing. I cannot do better than quote verbatim Mr. Trelease's interesting account of the act of pollination, that of oviposition being, as already stated, absolutely the same as in *yuccasella*:

"Having withdrawn the oviduct, in doing which she moves up so that her head is about level with the stigma, or even before this organ is entirely freed, the moth usually proceeds to pollination; but it is not infrequent for two eggs to be laid between each two visits to the stigma, and, owing to her peculiar alertness, she appears to be even more easily frightened into omitting pollination than are the other species of Pronuba. Standing with her head at about the height of the stigma, with the short tongue projecting out in front, she uncoils her long tentacles from the compact mass of pollinia, which she carries similarly to the other Pronubas, only that small part of her burden which adheres to the bases of the tentacles being removed from it, and, raising her body on tiptoe, she very slowly saws the tentacles back and forth across the top of the stigma, generally following one of the three shallow grooves, and very carefully working their slender tips into the more or less gummy exudation over the central depression. Sometimes the operation is interrupted long enough to admit of the tentacles being coiled back against the load of pollen and again extended; but the curious manner in which her head is held back from the stigma, as a rule, prevents any of the main load from reaching even the marginal papillæ.

"On first witnessing this operation I was impressed by the much slower motion of the moth than usual and the evident care which she took to run the ends of the tentacles into the central depression of the stigma, which I then supposed to be solid. The subsequent discovery of the stylar canal, communicating with the ovarian cells, showed that it is into this narrow passage that she so carefully guides the tips of her tentacles with their modicum of pollen, and no doubt the abundant stigmatic secretion serves not only to foster the development of the nascent pollen tubes after pollination, but, wetting the tentacles, aids in the disintegration of her mass of pollinia. These, if really related to her work, would seem to have acquired their coherent structure as a means of facilitating their collection rather than as an adaptation to their removal bodily from the anther to the stigma, as is the case in orchids and asclepiads, where, however, special means of secure attachment to the insect accompany this aggregation of the pollen grains into a large mass."

A further interesting fact connected with the pollination of this species is that Professor Trelease discovered a purely black variety (which he describes as *aterrima*) of *Pronuba maculata* connected with the variety *graminifolia* (Wood) of *Yucca whipplei*, common in San Bernardino county. The actions of this black variety are similar to those of the typical form, and it is also diurnal rather than nocturnal in its movements. The method of gathering the pollen mass is thus described:

"Flying into a flower, the moth runs about the bases of the stamens after the manner of other species, then quickly clambers upon the inner side of a filament, and, with the tentacles extended over the pollinia, drags first one and then the other out of the anther cells, pressing them together under the throat, and subsequently compacting the mass together, much as *yuccasella* does the powdery pollen of other Yuccas, so that the ball finally consists of as many as ten or a dozen pollinia. So quick and energetic are the motions by which the pollinia are removed that the stamens are often shaken quite violently, as I have before noted in the more nervous attempts of *yuccasella*."

Pronuba yuccasella on the Pacific Coast.

Of the fleshy fruited Yuccas Professor Trelease was able to study, among others, *Yucca baccata* Torrey, which is pollinized by *Pronuba yuccasella*. While he was not able to observe the acts of pollination, all the circumstances and the facts which he obtained would indicate that it is precisely the same as described for other species of Yucca that are fertilized by this moth, and the fertilized flowers show "conclusively that the pollen is thrust well into the stigmatal canal," or in some cases apparently even into "the top of the ovarian cells, which, owing to the short style and the deep stigmatic notches, they [the moths] can reach easily with their long maxillary tentacles." The moths taken from flowers at Cabazon and San Diego are somewhat above the average in size, with the horny and chitinous parts somewhat darker than in the typical form, but specimens which he sent me cannot be considered to have even varietal differences, and find their counterparts in my cabinet in specimens from Dakota and Colorado.

Yucca rupicola Scheele, of southern Texas, and *Y. elata* Engelm., extending from southern Texas to southern Arizona, are both pollinated by *Pronuba yuccasella*, as Professor Trelease ascertained.

Pronuba synthetica.

Mr. Trelease was also fortunate enough to be able to study the operations of *Pronuba synthetica* on the flowers of *Yucca brevifolia*. This Pronuba is slower in its movements and slower to take flight than the other species observed, though he found it more active during the day than is *Pronuba yuccasella*. It takes wing less readily and then merely sails down to the ground. This indisposition to leave the flower may be connected with the almost constant high winds on the Mojave desert, where this Yucca most abounds. The fertilized pistils of this Yucca are quite noticeable, by comparison with those of other species, by their symmetry and lack of constriction or indentation so uniformly present in the Yuccas that are punctured by *Pronuba yuccasella* and *P. maculata*. The explanation is found in the fact that *Pronuba synthetica* pierces "the uppermost part of the style, conveying its eggs down to the ovary through the stylar channel, the course followed by the pollen tubes." This fact interested me very much, for I recollected very well in my first studies of *Pronuba yuccasella*, before the act of oviposition had been witnessed, that, puncturing for the purpose of oviposition being unrecorded and therefore quite exceptional among Lepidoptera, I was strongly of the opinion that the egg would be thrust through the stigmatic opening down the stylar channel. The instinct to oviposit only on the youngest flowers is particularly marked in *synthetica*, which Trelease frequently saw forcing itself into the narrow clefts between the rigid sepals of the opening bud, the flattened form of the insect facilitating the operation. This habit also suggests the cause of the looseness of the wing scales and the ease with which they are lost. Mr. Trelease's observations in detail on the actions of this Pronuba cannot well be condensed, and I quote them entire:

"When about to deposit an egg, having selected a suitable flower, the female of *synthetica* runs to the bottom of the stamens much as *yuccasella* does, makes a rapid, more or less complete circuit of their bases, and then quickly ascends to the very top of the pistil, her thorax rather higher than the end of the stigma, and with her short but strong ovipositor cuts through the thin wall, into the stylar channel, rarely as much as 2 mm. below the tip of the stigma, meantime holding fast to the pistil, the stamens being below her reach. The long extensile oviduct is then passed through the puncture, the egg being laid apparently within the ovarian cell, along the funicular end of the ovules. In removing the oviduct the

moth not infrequently carries her body across the stigma, so that at first sight she appears to be withdrawing it directly from the mouth of the stylar canal; but I have never seen her make direct use of this canal. The operation consumes more time than does the oviposition of either *yuccasella* or *maculata* as I have observed them, and usually takes altogether from two and a half to three minutes. Sometimes two or more eggs are laid before the stigma is pollinated, but commonly after laying each egg the moth retreats to the bottom of the flower and then again ascends the pistil until her head is brought even with the stigma, when she uncoils the large tentacles from their resting-place against her load of pollen and passes them back and forth in the stigmatic chamber, with almost the same motion as the eastern species, usually making use of one of the stigmatic notches. While so employed she carries the rather short tongue almost straight out above the stigma, but I have never seen her make any use of it to force pollen into the latter, nor has she been observed to attempt to feed on the slight stigmatic secretion, nor to search for food at the base of the flower, where, if anywhere, the nectar of the septal glands should be found."

Professor Trelease has not yet published anything upon the other species of Yucca insects which he collected, and I take this occasion to present some few unrecorded facts in reference to some of the species of Prodoxus which he was kind enough to send me, as also some additional data from other sources.

The Species of Prodoxus.

Prodoxus coloradensis.—This was described by me from a single male taken in 1884 by Mr. H. K. Morrison in Colorado. In April, 1892, Mr. F. V. Coville, the present botanist of the Department of Agriculture, gave me a few small pieces of the flower-stem of a Yucca infested by a Prodoxus larva. The plant was collected in the Charleston mountains, Lincoln county, Nevada, the previous February, and was undoubtedly *Yucca baccata*. From these pieces of stem I reared early in the present month two imagos which proved to be *Prodoxus coloradensis*.

I have also received from Professor Trelease four other collected specimens, rather battered and imperfect, which belong to this species, all taken from the flowers of *Yucca baccata* at Banning, California. These two bred specimens are constant and agree thoroughly well with the type, except that there is no inclination to pale yellowish in the white scales of the head, and the thorax shows some black scales on the tegulæ, a line of black around the collar, and, in one of the specimens, along the

middle of the thorax; characters not noticeable except in well-preserved specimens. The white portion of the antennæ extends also in these two specimens beyond the basal third and fully to one-half the length of the organ. The four collected specimens from Professor Trelease indicate considerable variation; in one specimen the outer arm of the transverse Y-band across the posterior portion of the wing being absent, while in another it is broken, as is also the basal portion of the median band. The same is true of the band across the middle of the wing, while the upper portion of this band is connected with the basal band. The larva shows no striking characteristics, but is very similar to most other Prodoxid larvæ, being uniformly yellowish-white, the head and cervical shield anteriorly slightly darker, the ocelli black, and the mandibles brown and three-toothed.

Prodoxus reticulatus.—One of the specimens received from Trelease taken in flowers of *Yucca whipplei*, variety *graminifolia*, at Arrowhead Springs, in California, would indicate that this species, which I described from three females from Los Angeles county, California, and the habits of which were not known, breeds in some part of this Yucca. The single female sent by Trelease is interesting in that it shows some variation in the direction of *coloradensis*, especially by the separation of the basal half of the W-shaped band.

Prodoxus cinereus.—A section of the flower-stem of *Yucca whipplei* sent me by Mr. Coquillett last July contained a number of different larvæ, and among them most numerously one which subsequently proved to be the larva of *Prodoxus cinereus*. We have known that this species breeds in the main stem of this Yucca, but none of the early states had been observed. The larva is remarkable in that it differs materially from the typical Prodoxus larva. It is, first of all, very much more elongate, with the sutures between the segments more strongly impressed. It is, further, more uniform in diameter than the typical Prodoxus larva; but the most striking feature is the anal segment, which bears on its ventral plate two stout, brown, decurved horns resembling those of the larva of Trogosita in Coleoptera, except that these are curved in the opposite direction. I add a technical description:

Prodoxus cinereus. *Larva.*—Average length when full grown, 8.25 mm.; body elongate, but slightly curved, the joints moniliform; head rather large, more horizontal, and more free than in other species, light brown in

color, darker anteriorly; borders of clypeus almost white; pigment spot around ocelli, and the mandibles dark brown; the Y-shaped lines distinct and having exactly the outline of a rather narrow wine glass; cervical shield pale, but fuscous around the borders and especially at the middle of the anterior border; sinuate laterally and cleft posteriorly by the pale mesial line; characteristic feature a pair of decurved, dark, horny anal hooks, situated on the ventral apex; anal plate but faintly chitinous and with a fuscous mark upon it; a sub-ventral depressed line but faintly indicated and more highly polished than the rest of the surface; spiracles extremely small, with a faint yellow annulus, the prothoracic pair situated on the sub-ventral depressed line, the others much higher up on the anterior third of the segments; no thoracic legs, but slight tubercles in place of them; general color faint bluish-green or yellowish-green, losing color, however, in alcohol.

Pupa.—Offering no peculiar structures, but presenting the characteristics of the other species of the genus; skin very delicate; the cephalic projection not very prominent and the anal tip absolutely smooth; dorsal spinules reduced almost to obsolescence. The shrunken larva skin with its two strong hooks remains attached to the tip of the body of the pupa, and doubtless serves to hold it secure when it pushes from the surface of the thin epidermis to give forth the imago.

The imagos issued from the 11th of April to the 8th of May, the antennal sheaths and leg sheaths of the pupa separating, the former curling very much, as in other Lepidopterous pupæ which have wood- or pith-boring larvæ.

Prodoxus æneseens.—Professor Trelease has sent me a full account of the oviposition of this species upon *Yucca whipplei*, and it corresponds in every particular with the oviposition of *Prodoxus decipiens* in the East. In this case the species is not confined to one or the other of the forms of *whipplei*, but occurs on both the typical form and the variety *graminifolia*.

Prodoxus intermedius.—This species was described from two female specimens taken in Texas and one taken in Colorado, in 1887. It is a most interesting form, bearing an even more deceptive resemblance to *Pronuba yuccasella* than does the much commoner *Prodoxus decipiens*. For though the female lacks the remarkable maxillary tentacles of Pronuba, the ovipositor is long and delicate, very much as in the latter species. I have been anxious, since publishing the original description, to obtain a male of this rather puzzling species, and, fortunately, Professor Trelease sent me specimens associated with the females. On a superficial examination the males of this species would be separated with great difficulty from the males of *Pronuba yuccasella;* but upon denuding the genitalia the differences at once appear,

and it is curious to note that while the form of the genitalia, though showing slight variation, corresponds with that of *Prodoxus decipiens*, yet the claspers agree more nearly with those of *Pronuba yuccasella*, in having but the one large tubercle.

Prodoxus intricatus sp. nov.—I recently received from Mr. J. T. Mason, who has been kind enough to observe and collect some of the Yucca insects for me, a number of specimens of a Prodoxus which he found in the flowers of one of the tree Yuccas in Jalapa, Mexico. He sent also flowers and sections of one of the leaves of the Yucca, which, from this material, appears to be, without much doubt, *Yucca guatemalensis*. The moths were found abundantly in the flowers, but unfortunately reached me in rather dilapidated condition. The species is of the same general size as *Prodoxus reticulatus*, and with a somewhat similar but more varied and less distinct maculation. It is, however, a much darker species. I would simply characterize the species here, by comparison with *reticulatus*, with a view of adding one more link in our knowledge of the Prodoxids associated with the different species of Yucca.

In size and general appearance most nearly related to *P. reticulatus*, the general color, however, more sordid, the lighter shades inclining to pale fulvous, with a slightly golden sheen. Primaries more acuminate at apex, and marked with black scales, taking on, in a very general and indefinite way, the pattern of those of *reticulatus*. Secondaries also more acuminate at tip and blacker. Fringes of all wings black. Under surfaces fuliginous, with the faintest trace of pale marks on the costa of primaries. Anal claspers of male short, recurved upward, with a rather angular production on the inferior margin, and with three minute, but distinct, black teeth. There is also a similar black tooth on the inner margin near the tip. Ovipositor of female similar to that of *reticulatus*.

Some of the darker specimens present an almost black appearance, the black marks inclosing narrowed, luteous spaces, which appear like so many spots.

Described from 20 males and 5 females, none of them in perfect condition.

Conclusions.

The additional facts which I have thus presented upon this subject of Yucca insects and Yucca pollination serve to confirm the generalizations which I have already indulged in. So far as variation is concerned they add still further links to the chain of alliances between the different forms of this interesting family,

Prodoxidæ. The black form of *Pronuba maculata* presents us with the question of varietal or specific value that has arisen with the plant itself upon which it occurs, so far as regards the variety *graminifolia* of *Yucca whipplei*. Most specialists would be inclined, without any intermediate specimens, to characterize this black form as a distinct species, especially as it is dissociated from the other more typical forms and confined to one particular variety of Yucca. Yet in every other character but color it agrees precisely with the typical *maculata*, and I am strengthened in my view of considering it a mere variety by the well-known variation in the maculation of the typical species. It is a form that is differentiated as to color without having yet acquired any essential structural differences, though it may have lost the power to intercross with the typical form. Here, also, the color must be looked upon as of secondary importance to the species, and more or less fortuitous, as it is difficult to see what advantage the purely black has over the maculate form, especially in an insect essentially diurnal.

So it is in the variation of the banded species of Prodoxus. Some of the specimens combine the characters of at least two different species, without being referable to either, satisfactorily, and in the present state of our knowledge most entomologists would be justified in describing them as distinct species; but there can be little doubt that, when abundant material from different localities is obtained, all these transversely-marked forms will be difficult to separate. Such, however, is the case in almost every genus, whether of plants or animals, and the Prodoxids simply furnish us with a rather marked illustration of the fact that the variation has gone on and is going on, so far as purely colorational characters are concerned, without any very definite and unchangeable differences having yet been acquired. How strikingly such facts compare with the permanency, even in colorational characters, of such well-established species in the same order as the cosmopolitan *Vanessa cardui*, which, with a most beautiful wing design and a most complex colorational pattern on the inferior surfaces, remains essentially constant in all its details in all parts of the world where it is known.

The decurved hooks in the larva of *Prodoxus cinereus* are also most interesting from an evolutional point of view. Such anal hooks are extremely rare in Lepidopterous larvæ, being found in

only a very few pith-boring or stem-boring species.* We have in this structure, which is so exceptional in Lepidoptera, another illustration of a principle to which I have often referred in my writings, namely, that larval structure in insects has been modified independently of the ultimate structure, and is, as a consequence, of very little taxonomic value. Thus we have in this same family the larvæ of Prodoxus, (e. g., the typical *decipiens*) which remain in their short burrows, possessing no legs, while those of Pronuba, which quit their burrows and penetrate the ground, possess thoracic legs. Yet in the particular case of *Prodoxus cinereus* the larva approaches Pronuba in having thoracic tubercles which may be looked upon as either remnants of legs or the beginnings of the development of such. This larva burrows in the soft pith of *Yucca whipplei* much more freely than any of the other species of the genus so far studied, making much longer channels, the substance of the stem being less firm than that of the other species of Yucca. In so far, therefore, as this particular Prodoxus larva has peculiar structures, we can trace their origin to purely dynamic influences, assisted by heredity and selection—a consequence, in other words, of environment—and repeated independently in larvæ of different orders having no possible genetic connection.

The distribution of the genus Pronuba, as exemplified in these additional observations, is extremely interesting. *Pronuba yuccasella*, the typical species of the genus, not only occurs over

* I have not had time to closely scan the literature for cases of this kind, but do not recall any. I am familiar, however, with three unrecorded instances, two of them of Pterophorid larvæ which bore the stems of Solidago. One is the larva of *Alucita kellicottii* Fish, which singularly departs from the typical Lepidopterous larva in its elongated body and in having a pair of supra-anal spines which give the anal plate an appearance so characteristic of that of many Coleopterous larvæ. The second case is that of an undescribed species of the same family, Pterophoridæ, which has the anal plate obliquely truncate and fringed with a row of stiff hairs and with a pair of small thorns at its ventral border, this modification also recalling that possessed by several wood-boring Coleopterous larvæ. The third case is that of the larva of a Noctuid, *Hadena stipata* Morr., which burrows in the pith of young corn or maize. It has the anal plate obliquely truncate and flattened along the posterior margin, which is armed with a series of horny points, and thus again repeats the structure which recurs in certain Coleopterous larvæ, especially of the Elateridæ, which inhabit burrows in the trunks of trees.

half the continent, as I have previously shown, but extends to the Pacific coast and is found as far south as San Diego, showing over this wide range absolutely no differences that would justify varietal designation. All the characters are absolutely the same, and the rather dark coloring of the horny and chitinous parts of the body in the California, Dakota, and Colorado specimens would indicate that the western forms have this peculiarity as compared with the eastern. This species is now known to pollinize all the true Yuccas so far studied, and accompanies them across the continent. It thus pollinizes *Yucca filamentosa* and its several forms in the northeast; *Y. gloriosa* and *Y. aloifolia* in the southeast; *Y. angustifolia* (*glauca*) in the Rocky Mountain regions; *Y. rupicola* and *Y. elata* in the southwest; and *Y. baccata*, which connects the territory of *Y. angustifolia* with that of *Y. brevifolia* and *Y. whipplei*. It thus occurs in the same territory as its two congeners, *Pronuba synthetica* and *P. maculata*, with its *aterrima* variety, while these last are restricted to their respective Yuccas. This fact, as Professor Trelease has pointed out, strengthens the inference that *brevifolia* and *whipplei* are primary Pacific coast types, while *baccata* is an immigrant from the east. It remains yet to observe the pollinizers associated with *Yucca filifera*, *Y. australis*, *Y. treculeana*, and *Y. guatemalensis*, each of which will probably have a distinct Pronuba, while the other Yuccas not enumerated here will probably not have distinct species connected with them.

It would carry me too far to speculate further on the additional facts brought forth, but I would urge in conclusion that in all Mr. Trelease's interesting observations in his special studies of these different species of Yucca, and after having paid particular attention to the point, he has failed to see a single Pronuba in any species attempt to feed on either the stigmatic secretion or the septal nectar. He was also unable to convince himself that in any case the insect makes use of the tongue in pollination, as he once thought it might. In this and other respects he fully confirms the conclusions which I have drawn in my previous communication to the Society, while the additional data which I have indicated give further force to my remarks upon variation, as exemplified by these Prodoxids.

Vol. VIII, pp. 55-70 June 20, 1893.

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

DESCRIPTION OF A NEW WHITE-FOOTED MOUSE FROM THE EASTERN UNITED STATES.

BY GERRIT S. MILLER, Jr.

A critical study of over five hundred specimens of Sitomys collected in the northeastern United States and adjoining British provinces leads me to the conclusion that two distinct though somewhat closely related animals are at present confused under the name of *Sitomys americanus*. The two forms may be distinguished by the following diagnoses:

Ratio of tail vertebræ to total length ranging from 40 to 47.9; pencil, 2 mm. to 5 mm.; tail often not sharply bicolor; young usually passing directly from the plumbeous first coat to the russet-brown pelage of the adult, which is thus present in the great majority of specimens. . . . . *americanus*.

Ratio of tail vertebræ to total length ranging from 46.5 to 53.6; pencil, 4.4 mm. to 11 mm.; tail always sharply bicolor; young always passing through a gray phase between the plumbeous first coat and dull yellowish brown pelage of adult, which is thus comparatively seldom met with. . . . *canadensis*.

Sitomys americanus canadensis subsp. nov.

Hesperomys myoides Baird. Mam. N. Am., 1857, 472 (probably in part only), not *Cricetus myoides* Gapper.

Subsp. Ch. Somewhat larger than *Sitomys americanus* (Kerr), with longer, more hairy tail, and duller, less russet coloration;

young always passing through a gray phase before assuming the fulvous pelage; tail always sharply bicolor.

Adult (♀ No. $\frac{16}{1409}$, collection of G. S. Miller, Jr., Peterboro, Madison county, N. Y., July 24, 1892); length, 200*; tail vertebræ, 100; pencil, 6.6; hind foot, 21.4; ear from notch, 19; ratio of tail vertebræ to total length, 50. Fur everywhere except on lips and chin, slaty plumbeous at base. Dorsal surface wood-brown, slightly tinged with yellow, and very sparsely sprinkled with blackish hairs, which form a faint, ill-defined dorsal stripe; area between ears somewhat grayer; ears thinly clothed with whitish hairs internally, externally with brown; a whitish tuft at anterior base of ear; whiskers reaching about to shoulders, mixed blackish and silvery; tail sharply bicolor, white ventrally and at extreme tip, Vandyke brown above; dorsum of manus and pes, together with whole ventral surface, soiled white.

Young in gray phase (♀ No. $\frac{1638}{1435}$, collection of G. S. Miller, Jr., Peterboro, Madison county, N. Y., August 1, 1892); length, 201; tail vertebræ, 105; pencil, 11; hind foot, 21; ear from notch, 17.8; ratio of tail vertebræ to total length, 52.2; contained three embryos. Color of dorsal surface intermediate between broccoli-brown and smoke gray, with a slight admixture of blackish hairs as in adult, and a very faint trace of a narrow yellowish line bordering white of belly; a clear smoke-gray area between ears; otherwise colored like adult, except that the dorsal stripe on the tail is somewhat darker.

On comparing over one hundred specimens of *Sitomys americanus canadensis* with about four hundred skins of *S. americanus* the longer, more hairy tails and, as a whole, grayer color of the former are very noticeable. Three "stages of development" may conveniently be recognized in these mammals: first, the plumbeous young; second, fully grown and sexually mature individuals with the teeth still unworn, and, third, old animals with worn teeth. In the first stage there is nothing to distinguish the two subspecies except the longer, more hairy tail of *S. canadensis*. Specimens in the second stage differ most markedly, as *S. canadensis* is now gray, while *S. americanus* has, for the most part, assumed the russet coat. In the third stage again the two forms resemble each other somewhat closely, since both are now in the fulvous pelage; *canadensis*, however, may always be distinguished from its smaller relative by its longer, more hairy, and

* All measurements are in millimeters, unless otherwise specified.

more sharply bicolored tail and paler, grayish yellow color, without trace of the russet usually seen in *americanus*, and much less distinct dorsal stripe.

The differences in color characterizing these two animals are rather difficult to describe, but nevertheless they are of such a kind as to appeal immediately to the eye, especially when specimens in the flesh are examined. In many adults of *S. canadensis* the color of the dorsal surface is nearly homogeneous yellowish-brown or grayish-brown throughout, with merely the faintest possible trace of darkening in the mid-dorsal region. There is usually an indication of a very narrow yellowish line separating the color of the sides from the white of the belly. This is apt to be more distinct in the region of the cheeks and neck. The white ventral surface has frequently a soiled yellowish cast, which is oftenest met with in mid-summer. The pencil is usually white, and this color frequently involves the whole tip of the tail, sometimes for a distance of 30 mm., a feature very rarely seen in the shorter-tailed *S. americanus*. Grayish examples of *americanus* are sometimes met with among specimens taken in the summer, but with the exception of these very few of the smaller race approach in color even the brightest individuals of *S. canadensis*. In the gray phase *Sitomys americanus canadensis* bears a somewhat close resemblance to *S. americanus arcticus* (Mearns), the type of which in the Museum of Comparative Zoölogy at Cambridge, Mass., I have examined. The former may, however, be at once distinguished by its much longer tail, proportionally longer than in *americanus*, instead of proportionally somewhat shorter, as is the case with *arcticus*.

So far as I can see, *Sitomys americanus canadensis* shows no cranial or dental characters to separate it from its near allies.

As in all members of the genus, there is here considerable variation in actual size as well as in proportions. This variation for each form (*americanus* and *canadensis*) proves to be much less than recent writers have generally accredited to "*Hesperomys leucopus*." Both Allen (Bull. M. C. Z., 1, 1869, 227, 228) and Coues (Monog. N. Am. Rod., 1877, 53) allow a large range of variability in the ratio of tail vertebræ to total length. Nevertheless, this character proves to be sufficiently constant to be of considerable diagnostic value. Mr. Allen says (l. c., pp. 227–228): "But the most variable character consists in the relative length * * * of the caudal vertebræ. About one-fifth of the Massachusetts

specimens (of "*H. leucopus*") have the tail vertebræ equal to or longer than the head and body. * * * At least four-fifths, however, have the tail shorter than the head and body, and occasionally one occurs with the tail only equal to the body alone. In these latter the proportional length of the tail vertebræ to the length of the head and body is as 68 to 100; in the other extreme, or in those with long tails, as 118 to 100. The variation between these extremes is hence fifty per cent. of the mean—a striking example of the unreliability of this character as a specific distinction. * * *"

Dr. Coues repeats Mr. Allen's observations, adding: "The variation in absolute and relative length of the tail is greater than in any other dimension. * * * But this ceases to be remarkable when we recollect that it is purely a matter of what has been aptly called 'vegetative repetition.' It seems to be a well-nigh universal law that those parts or organs that are least specialized—*i. e.*, those of which several have the same or corresponding character and function—are liable to be produced with a high degree of irregularity as regard their number, and the more such there are the wider are the limits of variation apt to be. In this species, one of our longest-tailed rodents, the law is perfectly illustrated."

A glance at the appended tables of measurements and ratios of two hundred and fifty white-footed mice from the eastern United States and adjoining British provinces will show the incorrectness of the views quoted above. The range of variation in ratio of tail vertebræ to total length is in *S. americanus* from about 40 to about 48, while in the longer-tailed *S. a. canadensis* the variation is from 47.4 to 54.2. That Dr. Coues and Mr. Allen should have fallen into this error is probably due to the fact that their measurements were taken in part from distorted skins or alcoholic specimens, and also to the confusion of the two races under one name. The measurements here tabulated were all taken from the fresh specimens before skinning, and, unless otherwise stated, the writer is responsible for their accuracy.

So many names have been proposed for white-footed mice from eastern North America that it may appear somewhat hazardous to institute still another; hence the species described by authors from the region of importance in the present connection may well be considered here in some detail.

The first is, of course, the *Mus agrarius americanus* Kerr (An. Kingd., I, 1792, 231, based on Pennant, History of Quadrupeds, "No. 302B").* The description given by Pennant makes special reference to the mixed "dusky and ferruginous" color of the back and "orange coloured" sides of his American Field Rat, terms which refer unequivocally to our smaller and better-known animal. Any doubt in the case is dispelled by the addition by Pennant in the Arctic Zoölogy (I, 1784, 131), "length, about four and a half inches; of tail, four inches;" thus showing that it was the short-tailed form that he had in mind.

On Pennant's animal was based also the *Mus sylvaticus noveboracensis* of Fischer (Synopsis Mammalium, 1829, 318), the habitat of which is given as "in Novo Eboraco," and in all probability the *Mus noveboracensis* of Selys Longchamps (Etudes d'-Micromammalogie, 1839, 67), since this author remarks that the animal is a good species, although considered merely a variety by previous writers. That it is clearly the short-tailed animal that Selys Longchamps refers to is shown by the following extracts from the original description: "Son pelage est d'un fauve plus vif sur les côtes de la tête et du corps. * * * Longeur totale, 6 pouces 2 lignes; du corps, 3 pouces 6 lignes; de la queue, 2 pouces 8 lignes." This mouse is said to replace in North America the European *Mus sylvaticus*.

Rafinesque's *Musculus leucopus* (American Monthly Magazine, III, 1818, 446) is named among the ten new species of "wild rats" met with by that prolific describer of species during "a journey through the western region of the United States"—that is, in the Ohio valley and the pine barrens of Kentucky. As there is little chance that the range of *Sitomys canadensis* extends to that region, the name is hardly worth considering here. It may be mentioned, however, that Rafinesque's animal is said to be "fallow above," an expression which might apply fairly well to *S. americanus*, though hardly to the larger form.

The next name to be considered is the *Cricetus myoides* of Gapper (Zoölog. Journ., V, 1830, 204, pl. x). This animal, from the region between York and Lake Simcoe, Canada, is described as having the "upper half of the body mixed black and light reddish or yellowish brown." It is further stated that "it measures $3\frac{3}{4}$ inches from the tip of the nose to the insertion of the tail; the

*Synopsis of Quadrupeds, 1771, p. 303, No. 320A (American Field Mouse). History of Quadrupeds, II, 1781, p. 444, No. 302A.

tail itself, 3¼ inches." Thus color and measurements alike refer to *S. americanus*. Moreover, two white-footed mice kindly sent me in the flesh by Mr. I. R. Bourchier, of Sutton, West Ontario, Canada, just south of Lake Simcoe, are perfectly typical of the smaller form.

Arvicola emmonsii De Kay, from Massachusetts (in Emmons' Report on the Quadrupeds of Massachusetts) is clearly a synonym of *americanus*. The color is given as simply "brown above, darker along the back than the sides," but the whole length is stated to be 6 inches; tail, 2.5 inches. This animal is said to inhabit "*meadows* and wooded places. It is often seen in *fields recently mowed*, and is known by the name of Deer Mouse" (italics mine). *Sitomys americanus canadensis* never occurs in fields and meadows, where, however, *S. americanus* is often found.

Wagner's *Hesperomys maniculatus* (Wiegmann's Archiv., XI, 1845, Bd. I, 148*), from the Moravian settlements in Labrador, is described as "supra fuliginoso brunneus * * * Körper 3″ 2‴, Schwanz 2″ 5‴." In Beiträge zur Kentniss der Säugthiere Amerikas (Abhandl. Ak. Wiss. Wien, 1848, 315, 316) the author gives practically the same diagnosis, followed by the remarks: "Gestalt, Grösse und Farbenvertheilung verhält sich wie bei *H. leucopus*, so dass ich nur die Differenzen anzugeben brauche, welche sich zwischen ihr und dem letztern, von dem ich dermalen nur Beschreibungen, und zwar zunächst die Richardson's vergleichen kann, ergeben. Diese Abweichungen bestehen darin, dass bei *H. maniculatus* die Oberseite weit trüber gefärbt ist, indem sie namlich blos russig gelblichbraun und schwarz gesprenkelt ist, ohne Beimischung von Rostroth vie es von *H. leucopus* angegeben wird." This description is somewhat puzzling, and without specimens from the coast of Labrador it is impossible to decide just what animal it refers to. That *S. canadensis* is not Wagner's animal is shown by the measurements, which being taken from "2 Weingeist Examplaren" must be fairly accurate.

Hesperomys campestris Le Conte, from New Jersey, is described so vaguely (Proc. Ac. Nat. Sci. Phila., VI, 1853, 413) that, to use Professor Baird's words (Mam. N. Am., 1857, 485): "Of the affinities of this animal I will hazard no conjecture." That it is not the same as *S. canadensis* is shown by the measurements—length,

*Not "1843, II, 141, and 1845, II, 148," as given by Baird and Coues.

3.4 inches; tail, 2.7 "—which were taken from an alcoholic specimen.

The next name to be examined is the *Hesperomys gracilis* of Le Conte (Proc. Acad. Nat. Sci. Phila., VII, 1855, 442). Le Conte states that the animal "inhabits Michigan; Professor Baird." From the description, "dark slate color above, a little tipped with brown," it seems probable that the type specimen was immature. There are some discrepancies between the measurements given in the original description and those of the same specimen given by Baird (Mam. N. Am., 1857, 473). According to Le Conte, the length (head and body) is 3.8 inches; tail, 4, while Baird gives the dimensions of the same parts as 3.60 and 3.70 inches respectively. The latter author adds that the body is stretched. The long tail of this specimen might suggest the possibility of its being the same as my *canadensis*, but on account of its poor condition and the vagueness of the description, it seems wisest to discard the name entirely as undeterminable. Moreover, Baird states that the pencil of the type is 0.10 in. (2.5 mm.) in length, which is much less than in any specimens of *S. canadensis* that I have seen.

While not wishing to enter here into a general discussion of the relationships of *Mus michiganensis* Aud. and Bach., and *Mus bairdii* Hoy and Kennicott, a few words concerning the probable bearing of these animals on the present case may not be out of place. *Mus michiganensis*, from Erie county, Michigan, is described (Journ. Acad. Nat. Sci. Phila, VIII, pt. II, 1842, 304) as a "mouse with yellow cheeks, a light grayish-brown color above, whitish below. * * * The feet, nails, ears, and tail are light brown." It is farther remarked that "there is no distinct line of demarkation between the colors of the back and under surface, nor does the white extend along the sides as in the white-footed mouse. Dimensions: length of head and body, 4 inches 0 lines; length of tail, 2 inches 6 lines." That this animal cannot be the same as *S. canadensis* is shown by the short tail and peculiar coloring of the feet and sides.

The description of *Mus bairdii* (Rep. Com. Patents for the year 1856, published in 1857, p. 92) from northern Illinois and southern Wisconsin refers to some short-tailed, bright-colored mouse quite unlike *Sitomys a. canadensis*, as the following extracts will show: "Length of the adult male, from nose to root of tail, $2\frac{3}{4}$ inches; tail (vertebræ), $1\frac{3}{4}$ inches; hind foot, $\frac{3}{4}$ of an inch. Head

and body of a large male, $3\frac{3}{4}$ inches; tail, 2 inches. In another specimen, the head and body $3\frac{3}{16}$ inches; tail, $1\frac{3}{4}$ inches. In spring the hairs of the upper parts are plumbeous at the base, tipped with ashy and yellowish brown; a few longer hairs, entirely black, interspersed. The tips of most of the hairs deepen into black along the back, giving a broad, black stripe when the hair lies flat. In some specimens this stripe is not so dark as in others, but is quite distinct in all, while in some it is pitch-black." It will be remembered that one of the noticeable color features of *S. canadensis* is the indistinctness of the dark dorsal stripe; hence *Mus bairdii*, whatever it really may be, is a very different species.

The animal from Burlington, Vermont, described by Baird under the name of *Hesperomys myoides* (Gapper) (Mam. N. Am., 1857, p. 472), is, in part at least, the same as the subject of the present paper. Baird remarks that "all the white-footed mice from near Burlington, Vermont, had much longer tails in proportion than those from Middleboro, Massachusetts." The only specimens, three in number, that I have seen from the locality in question are, however, typical *americanus*. Baird's statement, "tail vertebrae generally .25 of an inch longer than head, and body with a decided pencil at the end," and also table of measurements on page 473, refer, without question, to the long tailed form; but his description leaves a slight doubt as to just what animal he had in hand. I have never seen a specimen of *S. canadensis* in which the color is "more vivid yellowish brown" than in *S. americanus*, nor do any resemble *S. aureolus* in color, as is said to be the case with "*H. myoides*." Baird considered the presence of cheek pouches to be the best diagnostic character of *myoides*. More recently, however, it has been shown by Allen (Bull. M. C. Z., I, 1869, 229) that these structures occur also in the common *S. americanus*. It is worthy of remark, in this connection, that I have found the cheek pouches of *S. canadensis* much the more frequently and conspicuously distended with food.

Sitomys americanus canadensis is exclusively a Canadian form, replacing *S. americanus* in the spruce forests of New Brunswick (Restigouche county, E. A. Bangs; Northumberland county, G. S. Miller), and extending south among the hills and mountains at least to central New York and western Massachusetts. *Sitomys americanus* is found as far north as Digby, Nova Scotia, and Lake Simcoe, Ontario. Thus the ranges of the two forms overlap

geographically about two hundred miles. Nevertheless, the conditions under which the animals live are essentially different, *S. canadensis* confining itself to dense, preferably damp woods—such as *Troglodytes hiemalis* and *Certhia familiaris americana* choose to breed in—while *S. americanus* is a mouse of the open fields, clearings, and neighborhood of houses. Only in the central and southern part of its range, where the character of the country is very different from that inhabited by *S. canadensis*, does the smaller animal take to the woods with anything like regularity. I have no doubt that the northward range of *S. americanus* has been considerably extended by a gradual movement, following the clearing away of the forests, thus bringing the two races into their now curiously close juxtaposition.

For the present at least I have thought it best to treat these two animals as subspecies. It must be confessed, however, that the number of intermediates is surprisingly small, less than a dozen in the total number of specimens examined, and that these occur in no particular geographical region. The case is susceptible of no definite proof until more facts are forthcoming; meanwhile it lies with each observer to treat these closely allied forms as his individual preference may dictate.

Measurements of One Hundred and Fifty Specimens of Sitomys americanus (Kerr).

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
2011	1763	Sutton, West Ontario, Canada.	Nov. 25, '92	♀	167	74	3.8	21.6	17	44 3
2012	1764	" "	Dec. 1, '92	♀	160	70	3.6	20	15.4	43.7
2231	.....	Digby, N. S.....	Oct. 9, '92	♂	166.5	80.5	3.4	20.5	17.5	47.7*
2232	.....	" "	" 9, '92	♂	164	78	2.8	20.5	16	47.5
2233	.....	" "	" 11, '92	♀	172	83	3	19.5	17	48.9
2234	.....	" "	" 13, '92	♀	167.5	82	4	19.5	15.5	48.3
2235	.....	" "	" 13, '92	♀	166.5	79	3.8	20	15	47.4
2236	.....	" "	" 16, '92	♂	163	79	3	19	17.5	48.4
2237	.....	" "	" 16, '92	♀	156.5	72.5	2.4	20	15.5	46.3
2238	.....	" "	" 17, '92	♀	154.5	70.5	3.4	20.5	16	44.9
2239	.....	" "	" 17, '92	♂	156.5	74.5	3	20.5	16	41.2
2240	.....	" "	" 21, '92	♀	157	71	3	19	17	45.2
2241	.....	" "	" 23, '92	♀	166.5	80	3.4	20.5	14.5	48.4
2242	.....	" "	" 23, '92	♀	159	73	2.4	19.5	15.5	45.9
1024	873	Elizabethtown, N. Y.	Dec. 20, '91	♀	169	74	3.6	20.4	17	43.1
1025	874	" "	" 21, '91	♂	165	74	3.4	22	16.8	44.8
1042	890	" "	" 27, '91	♂	170	76	4	20	16.4	44.7
1049	897	" "	" 28, '91	♀	180	79	3.2	19.5	16.2	43.9
1054	902	" "	" 29, '91	♂	167	68	3.2	20.4	16.2	40.7
1055	903	" "	" 30, '91	♂	162	68	3.6	20.4	16.2	41.9
1059	907	" "	" 31, '91	♂	168	74.8	3.6	21	14.8	44
1060	908	" "	" 31, '91	♀	160	71	3.4	20.5	15.4	44.3
1063	911	" "	Jan. 1, '92	♂	168	71	4.4	20	14	42.3
1065	913	" "	" 1, '92	♂	158	66.5	3	20.2	14 8	42.1
1066	914	" "	" 1, '92	♂	158	70	3	20	15.6	44.3
1140	967	" "	" 3, '92	♂	181	83	4.2	21	17	45.8
1141	968	" "	" 3, '92	♂	169	71	3.4	21	17	44.1
1282	1109	" "	Feb. 27, '92	♂	166	74	3.6	21	16	44.6
1292	1112	" "	Mar. 10, '92	♀	154	69	2.8	20.5	15.5	44.8
1352	1169	" "	Apr. 3, '92	♀	163	68	3.2	20	16	41.7
1353	1170	" "	" 4, '92	♀	157	67	3	20	14.8	42.6
1355	1172	" "	" 11, '92	♀	172	71	3.8	19	15.2	41.3
1356	1173	" "	" 4, '92	♂	176	80	4	20	14.5	45.4
1357	1174	" "	" 5, '92	♂	175	76	2.8	19.4	16.8	43.4
258	.....	Peterboro, N. Y.	July 15, '90	♀	175	76	3.6	19.3	14	43.5
1595	1392	" "	" 20, '92	♀	192	86	4.4	21	16	45
1640	1437	" "	Aug. 3, '92	♀	172	76	...	20	16.4	44
1648	1444	" "	" 17, '92	♀	172	76	4	19	17	44
1649	1445	" "	" 17, '92	♂	185	80	4	20.8	18	43
1652	1448	" "	" 19, '92	♀	177	75	2.4	20.2	16.2	42
1653	1449	" "	" 19, '92	♂	164	72	3.4	20.6	16	44
1654	1450	" "	" 20, '92	♂	170	76	1.8	20.4	16	45
1683	1478	" "	Sept. 9, '92	♀	190	85	4.4	22	18	45
1708	1499	" "	" 17, '92	♀	155	69	2	19	17	45
1709	1500	" "	" 17, '92	♀	156	71	2	20	16	45
1710	1501	" "	" 17, '92	♂	167	76	3.4	20	17	46
1716	1507	" "	" 25, '92	♂	152	66	3.4	19.8	14.4	43.4

*Collected and measured by Outram Bangs.

Measurements of One Hundred and Fifty Specimens of Sitomys americanus (Kerr).

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
1097	1760	Peterboro, N. Y.	Nov. 9, '92	♂♀	168	75	3	22	16	44.6
283	.....	Geneva, N. Y....	Dec. 25, '90	♀	165	71	3.4	20.4	17	43
284	.....	" "	" 27, '90	♀	165	72.5	3.8	19	16	43.3
1153	980	West Dedham, Mass.	Jan. 30, '92	♂	184	82	3	20.4	14.5	43.5
1154	981	" "	" 30, '92	♂♀	178	78	3.2	20.8	15	43.8
1155	982	" "	" 30, '92	♂♀	163	69.6	3.2	20.5	16	42.7
1156	983	" "	" 30, '92	♂♀	169	72	3.2	21	15.8	42.6
1157	984	" "	" 30, '92	♂♀	183	82	4	20	16	44.8
1158	985	" "	" 30, '92	♂♀	165	70	3	21	15.8	42.4
1159	986	" "	" 30, '92	♂♀	179	78	3.4	21	14.8	43.6
1160	987	" "	" 30, '92	♀	172	79	4	21	15.2	45.9
1161	988	" "	" 30, '92	♀	165	72.5	4	20.5	15	43.9
1162	989	" "	" 30, '92	♀	179	78.5	3.4	23	16.5	43.9
1163	990	" "	" 30, '92	♀	173	76	5	20.2	17	43.9
1164	991	" "	" 31, '92	♂♀	162	69	3.4	20.5	14.8	42.5
1165	992	" "	" 31, '92	♂♀	167	76	3.6	20	15.4	45.5
1166	993	" "	" 31, '92	♀	163.5	72	3.2	19	13.5	44.3
1167	994	" "	" 31, '92	♀	163	72	4	21	17	44.1
1168	995	" "	" 31, '92	♀	163	70	3.8	20	14.8	42.9
1402	1218	" "	May 8, '92	♀	182	81	2.4	20	16	44.5
1173	1000	" "	" 1, '92	♂♀	171	74	3.4	20.5	15	43.2
1174	1001	" "	" 1, '92	♀	159	66	3.2	21.4	16.4	41.5
1175	1002	" "	" 1, '92	♀	174	77	5	20.2	15	44.2
1402	1218	" "	" 8, '92	♀	182	81	2.4	20	16	44.5
448	372	Seekonk, Mass...	April 6, '91	♀	195	88.5	3.4	20.8	17.2	45.4
919	805	" " ...	Nov. 28, '91	♂♀	179	79	4.6	21	14.8	44.1
920	806	" " ...	" 28, '91	♂♀	152	66	....	20.4	14.8	43.4
922	808	" " ...	" 29, '91	♂♀	167	87	3.4	20.2	15	46.7
923	809	" " ...	" 29, '91	♂♀	162	67.4	3.8	20.4	15	41.6
924	810	" " ...	" 29, '91	♂♀	184	85.5	2.8	20.8	15.8	46.5
926	812	" " ...	" 27, '91	♀	190	88.5	3 2	20.8	15.6	46.6
927	813	" " ...	" 27, '91	♀	171	76.6	3	20.5	15.6	44.8
928	814	" " ...	" 29, '91	♀	188	84	4.2	20.4	17	44.7
929	815	" " ...	" 29, '91	♀	181	76	4	20.5	15	42
931	817	" " ...	" 29, '91	♀	196	94	3	20.6	15.4	47.9
932	818	" " ...	" 29, '91	♀	163	75.6	3.6	20.8	16.4	46.4
933	819	" " ...	" 29, '91	♀	180	79	3.6	19.8	14.4	43.9
936	822	" " ...	" 30, '91	♀	178	75.5	3.2	19.8	15.8	42.4
2014	.....	" " ...	Dec. 12, '92	♀	193	86	4.2	20	16	44.6
2289	.....	Concord, Mass ...	Nov. 5, '92	♂♀	159	69	4	20	15	43.4
2290	.....	" " ...	" 5, '92	♂♀	158	69	3	20.4	15	43.6
1399	1215	Weston, Mass....	May 2, '92	♂♀	170	72	3	20.8	17	42.3
1400	1216	" "	" 2, '92	♂♀	180	79	2.8	20.8	16.8	43.9
1401	1217	" "	" 2, '92	♂♀	166	68	2.6	20	17	41
436	357	Ipswich, Mass ...	Mar. 21, '91	♂♀	176	82.5	3	20.5	16	46.9
437	358	" " ...	" 21, '91	♂♀	162	75	2.6	20	15.8	46.3
439	360	North Truro, Mass.	April 1, '91	♀	188	83.5	3	19.5	16.2	44.4
440	361	" "	" 1, '91	♀	156	66	3	19.5	17	42.3

Measurements of One Hundred and Fifty Specimens of Sitomys americanus (Kerr).

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
441	362	North Truro, Mass.	April 1, '91	♂	152	65	4	20	16	42.1
442	363	" "	" 1, '91	♂	148	67	3.2	20	16.4	45.3
443	364	" "	" 1, '91	♂	153	65.5	3	19.5	16	42.1
444	365	" "	" 1, '91	♂	156	68	3.6	20	14.5	43.6
451	366	" "	" 1, '91	♂	164	69	....	20	16	42.1
749	642	" "	Sept. 22, '91	♂	169	78	2.6	21	16.8	46.1
1422	1234	" "	May 22, '92	♂	182	85	....	21	17	46.7
1525	1331	" "	June 24, '92	♂	183	82	3	20.2	16.2	44.8
1527	1333	" "	" 24, '92	♂	167	74	....	20	17	44.3
1529	1335	" "	" 25, '92	♂	188	83	2.4	20	16	44.1
1530	1336	" "	" 28, '92	♂	175	80	2.4	21	15.4	46
1531	1337	" "	" 28, '92	♂	180	79	2.4	20	16.8	44
1	.....	Liberty Hill, Conn.	Nov. 21, '92	♂	178.5	78	3.8	20	17.5	43.2*
3	.....	" "	" 22, '92	♂	145	57.5	3	20	14	40
4	.....	" "	" 22, '92	♂	173.5	74.5	4	20.5	15	42.9
5	.....	" "	" 22, '92	♂	164.5	70	3.8	20.5	15	41.9
7	.....	" "	" 23, '92	♂	158	71	3	20.5	14.5	44.2
9	.....	" "	" 26, '92	♀	171	77	5.2	21.5	19	45
10	.....	" "	" 26, '92	♀	167.5	78.5	3.8	20	18	46.9
13	.....	" "	" 26, '92	♀	151	69	4	19	18	45.6
14	.....	" "	" 26, '92	♀	146	66	3.2	20	18	45.2
15	.....	" "	" 26, '92	♂	142	61	3.6	18	15	43
16	.....	" "	" 26, '92	♂	166.5	74.5	3.4	19	17	44.7
17	.....	" "	" 26, '92	♀	151	65	4.2	20	17	43
18	.....	" "	" 26, '92	♀	165	75	3.8	19	15	45.4
19	.....	" "	" 26, '92	♀	158	69	3.4	18	15	43.6
20	.....	" "	" 26, '92	♀	164	74	3.4	19.5	17.5	45.5
1	.....	" "	Dec. 14, '92	♀	175	80	3.4	20.5	17	45.7
1	.....	" "	" 15, '92	♀	173	73	3.8	21	15.5	42.2
13	.....	Haddonfield, N. J.	" 24, '91	♀	169	73	5	21.3	15.2	41.6†
15	.....	" "	" 24, '91	♀	165	74.7	3	19.3	16.3	45.3
18	.....	" "	" 24, '91	♂	141	62	3	19.3	15.7	44
30	.....	" "	" 26, '91	♂	152	66.5	4	20.3	16.3	43.7
32	.....	" "	" 26, '91	♂	143	63.5	3.6	19	14.7	43.7
38	.....	" "	" 27, '91	♂	155.4	71.6	3.2	20.3	17.5	46.1
51	.....	" "	" 28, '91	♂	156	66	3.6	19.3	15.7	42.3
57	.....	" "	Jan. 11, '92	♂	153	64	4	21.6	17	41.8
88	.....	" "	" 22, '92	♀	174	82	4.2	20.3	15.7	47.1
90	.....	" "	" 23, '92	♀	159	69.8	4.2	19.6	16	43.9
118	.....	" "	Feb. 2, '92	♂	171	74.2	3.8	23	17	43.4
125	.....	" "	" 3, '92	♂	152	67.3	4	21.3	16.5	44.3
146	.....	" "	" 13, '92	♂	165	73	4	20	16	44.2
152	.....	Thorndale, Pa....	" 18, '92	♂	157	67	3.6	21	10	42.6
134	.....	Barren Ridge, Pa.	" 7, '92	♂	161	67	3.4	21	15.2	40.3
135	.....	" "	" 7, '92	♂	149	58	4	20.3	15.7	39.6
58	.....	Marple, Pa.....	Jan. 13, '92	♂	152	63	3.8	21	16	41.4
61	.....	" "	" 14, '92	♂	157	67	4	20.3	15.2	42.6
71	.....	" "	" 15, '92	♂	140	57	2.4	20.3	16.8	40.7

*Collection of Outram Bangs; measured by collector.
†Collection of S. N. Rhoads; measured by collector.

Measurements of One Hundred and Fifty Specimens of Sitomys americanus (Kerr).

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
74	.....	Marple, Pa.....	Jan. 16, '92	♂	154	63	3	20.3	16	41
75	.....	" "	" 16, '92	♂	156	69	3.8	22	15.2	44.3
2132	1862	Washington, D. C.	Feb. 12, '93	♀	194	91	2	21	17	46.9
2133	1863	" "	" 12, '93	♂	185	85	2.8	20	15	45.9
2134	1864	" "	" 12, '93	♂	165	76	3.6	21	16	46.6
2135	1865	" "	" 12, '93	♂	177	84	3.4	20	16	47.4
2136	1866	" "	" 12, '93	♂	165	72	3	21	16	43.6

Measurements of One Hundred Specimens of Sitomys americanus canadensis Miller.

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
1436	.....	Northumberland Co., N. B.	June 6, '92	♂	170	83	....	19.8	16.8	48.8
1437	.....	" "	" 9, '92	♀	150	73	....	19.8	16	48.7
1419	1231	Oak Bay, N. B....	Apr. 11, '92	♀	155	75	5	19.8	15.6	48.4*
1848	1626	" "	May 18, '92	♀	185	90	6	20	16	48.6
1032	881	Elizabethtown, N. Y.	Dec. 23, '91	♂	181	91	7.4	20.2	17.8	50.3
1033	882	" "	" 23, '91	♀	197	100.5	8	20	17.4	51
1034	883	" "	" 23, '91	♂	170	84	6.8	19.4	16	49.4
1043	891	" "	" 27, '91	♀	165	82	5.6	18	17	49.7
1044	892	" "	" 27, '91	♀	165	86	6.8	20	17	52.1
1048	896	" "	" 28, '91	♂	178	89	7.4	20	16.8	50
1056	904	" "	" 30, '91	♂	196	100	7.8	20	17.2	51
1061	909	" "	" 31, '91	♀	184	91	6.8	20	16.5	49.5
1062	910	" "	" 31, '91	♂	166	81	6.6	19.8	17.6	48.8
1067	915	" "	Jan. 1, '93	♂	173	85	5.4	20	18.2	49.1
1142	969	" "	" 3, '93	♀	171	81	5.4	20.5	18	47.4
1143	970	" "	" 3, '93	♀	176	84	6	20	16.5	47.7
1181	1008	" "	Feb. 4, '93	♂	189	95	6.6	21	16	50.3
1208	1035	" "	" 17, '93	♂	170	83	4.4	21.5	15	49
1209	1036	" "	" 17, '93	♀	162	81	4.4	21.5	14	50
1223	1050	" "	" 19, '93	♂	185	92	4.6	21.5	15	49.7
1224	1051	" "	" 19, '93	♂	181	90	5.8	21.2	16	49.7
1284	1104	" "	" 21, '93	♀	168	85	4.6	22	17	50.6
1286	1106	" "	" 25, '93	♂	173	89.5	6.2	20	17	51.7
1287	1107	" "	" 25, '93	♂	170	85	6.4	19.5	16	50
1288	1108	" "	" 25, '93	♂	169	81	5	22	18	47.9

* Collected and measured by H. H. McAdam.

Measurements of One Hundred Specimens of Sitomys americanus canadensis Miller.

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
1365	1181	Elizabethtown, N. Y.	Mar. 28, '93	♀	160	80	4.8	19	18.5	50
1368	1184	" "	April 6, '93	♀	173	83	7.8	20.4	17	47.9
1369	1185	" "	" 6, '93	♀	186	88.5	6.4	20.4	17	47.6
1370	1186	" "	" 9, '93	♀	172	85	6	21	17.2	49.4
1371	1187	" "	" 4, '93	♂	179	86	7.4	20	17	48
1372	1188	" "	" 4, '93	♂	185	93	7.2	19.4	18	50.2
1373	1189	" "	" 6, '93	♂	187	90	8.2	21	18.2	48.1
1374	1190	" "	" 10, '93	♂	177	85	7.2	21	16.2	48
1375	1191	" "	" 10, '93	♂	181	88.5	7	21.2	19	48.9
1285	1105	" "	Feb. 25, '93	♀	172	85	3.2	20	17	49.8
1361	1178	" "	April 4, '93	♀	182	90	6.6	20.4	18.2	49.5
1362	1179	" "	" 9, '93	♀	193	92.5	7.8	20	16.8	47.9
1573	1370	Peterboro, N. Y.	July 17, '93	♀	172	85	6.8	20	17.6	49
1579	1376	" "	" 18, '93	♀	172	85	5.7	20	18	49
1580	1377	" "	" 18, '93	♀	200	100	6.4	21	18.8	50
1582	1379	" "	" 18, '93	♀	190	97	7.8	21.2	18	51
1583	1380	" "	" 18, '93	♀	182	95	7.4	21.8	17.6	52
1584	1381	" "	" 18, '93	♀	175	84	7	20.6	17	49
1585	1382	" "	" 18, '93	♂	196	102	6	21.4	18	52
1586	1383	" "	" 18, '93	♂	195	101	9	21	19	52
1587	1384	" "	" 18, '93	♂	195	98	7	21	17.2	50
1588	1385	" "	" 19, '93	♀	175	91	6	21	19	52
1589	1386	" "	" 19, '93	♂	196	98	7	21	19.2	50
1590	1387	" "	" 19, '93	♂	176	85	5.2	20.8	18	48.3
1591	1388	" "	" 19, '93	♂	165	84	5.6	20.	18	50.9
1593	1390	" "	" 19, '93	♂	187	92	7.8	21.6	18	49.2
1597	1394	" "	" 20, '93	♀	171	87	6 6	20	18	50.9
1598	1395	" "	" 20, '93	♀	172	87	5.6	19 8	19	50.6
1599	1396	" "	" 20, '93	♂	206	108	7	21.8	18.8	52.4
1600	1397	" "	" 20, '93	♂	188	99	6.6	21.8	16.8	52.7
1601	1398	" "	" 20, '93	♂	175	86.5	6.6	20	18.2	49.4
1602	1399	" "	" 20, '93	♂	185	96	6.8	21.8	19	51.9
1603	1400	" "	" 20, '93	♀	180	89	5.4	21.8	19	49.4
1606	1403	" "	" 21, '93	♀	175	87	7	21	19	49.7
1607	1404	" "	" 21, '93	♀	175	90	6	21	16.6	51.4
1608	1405	" "	" 21, '93	♂	188	94	9	21	18	50*
1610	1407	" "	" 21, '93	♂	179	93	5.4	20	18	51.9
1611	1408	" "	" 21, '93	♂	180	91	6	21.2	19.6	50.4
1612	1409	" "	" 24, '93	♀	200	100	6.6	21.4	19	50*
1613	1410	" "	" 24, '93	♀	195	100	5 4	21	19	51.3
1615	1412	" "	" 24, '93	♂	177	90	6.8	21	18	50.8
1619	1416	" "	" 25, '93	♂	180	93	5.2	21	18	51.7
1620	1417	" "	" 25, '93	♂	175	87	6.6	21	17.4	49.7
1621	1418	" "	" 25, '93	♂	178	90	5.4	21.4	18	50.6
1630	1427	" "	" 30, '93	♀	217	114	10.8	22	18.8	52.5
1638	1435	" "	Aug. 1, '93	♂	201	105	11	21	17.8	52.2*
1639	1436	" "	" 1, '93	♂	189	100	5	21	17	52.9
1642	1438	" "	" 5, '93	♂	170	83	7.8	20	17	48.8

*Type.

Measurements of One Hundred Specimens of Sitomys americanus canadensis Miller.

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
1643	1439	Peterboro, N. Y.	Aug. 5, '92	♂	176	85	8.2	20.2	17	48.3
1644	1440	" "	" 6, '92	♂	171	86	9.2	20.4	18	50.3
1645	1441	" "	" 7, '93	♂	180	96	6.8	21	18	53.3
1651	1447	" "	" 18, '93	♂	202	104	8	20.6	20	51.5
1655	1451	" "	" 22, '93	♂	195	103	8	19	19	52.8
1661	.....	" "	" 23, '93	♂	195	100	8	20	19.8	51.3
1662	1458	" "	" 25, '93	♂	188	101	5.8	21	20	53.2
1670	1465	" "	" 26, '93	♂	214	116	6.2	21.4	18.4	54.2
1671	1466	" "	" 26, '93	♂	202	105	7.4	21	18	52
1672	1467	" "	" 26, '93	♂	189	101	6.9	20	19	53.6
1680	1475	" "	Sept. 7, '93	♂	192	98	5	20.2	18.8	51
1681	1476	" "	" 7, '93	♂	187	92	6.1	22	18	49.2
1685	1480	" "	" 10, '93	♂	192	98	10	21	19.4	51
1686	1481	" "	" 10, '93	♂	183	94	9.4	22	19	51.4
1687	1482	" "	" 10, '93	♂	187	98	6.4	22.8	20	52.4
1688	1483	" "	" 10, '93	♂	183	95	7	21.8	18.4	51.9
1692	1487	" "	" 11, '93	♀	182	95	8.6	21.8	19.8	52.3
1693	1488	" "	" 11, '93	♀	172	87	8	20.2	18	50.6
1697	1491	" "	" 15, '93	♀	182	94	6.8	21	19	51.6
2003	.....	" "	Oct. 14, '93	♂	182	93.6	7.8	21	19	51.9
2004	.....	" "	" 19, '93	♀	173	90	7.4	20.4	18	52
2009	.....	" "	Nov. 3, '93	♂	180	94	8.4	20	17	52.2
2010	.....	" "	" 8, '93	♀	200	102	8.4	20	19	51
2292	.....	Mount Graylock, Mass.	May 8, '93	♀	198	96	7.4	22	19	48.5
2293	.....	" "	" 8, '93	♀	188	94	7	21.2	18	50
2294	.....	" "	" 8, '93	♂	200	103	9	22.2	17	51.5
2295	.....	" "	" 8, '93	♂	202	98	8	22.2	19	48.5

Vol. VIII, pp. 71-82, pls. X, XI July 13, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

DEVELOPMENT OF THE BRACHIAL SUPPORTS IN DIELASMA AND ZYGOSPIRA.

BY CHARLES E. BEECHER AND CHARLES SCHUCHERT.

It has been shown by several authors* that the brachial supports in the Terebratellidæ pass through a series of distinct metamorphoses during the life of the animal. In the higher genera, these stages may be correlated with the adult structures of lower forms, thus furnishing satisfactory data for a systematic arrangement of the genera and for their phylogenetic relations.

This kind of research naturally requires ontogenetic series of considerable completeness, and it is often difficult or impossible to obtain such material representing fossil forms. Moreover, the fossils must be exceptionally well preserved to afford a means of working out the development of a structure so delicate as the calcareous lamellæ supporting the brachia, especially in young specimens from one to five millimeters in length.

It first seemed desirable to determine the development in some genus of the Terebratulidæ from the Paleozoic, in order to ascertain whether the brachial supports as in Neozoic and recent forms passed through a series of transformations, and to determine the most primitive form of the loop in the Ancylobrachia. For this purpose, a species of *Dielasma* (*D. turgida*) obtained from Mr. Moritz Fischer was used. The specimens are

* Davidson, Friele, Deslongchamps, Fischer and Œhlert, and Beecher.

from the St. Louis group of the Lower Carboniferous in Kentucky. The shells are partially silicified, generally filled with transparent calcite, and afford very satisfactory preparations of the arm supports. It was found that the loop of *Diclasma* underwent transformations during growth, and that the earliest stage observed is like *Centronella*. This establishes the *centronelliform* loop as the simplest type of loop in the Ancylobrachia. Besides *Centronella*, other adult representatives of the same structure are *Rensselæria* and *Newberria*. They are all late Silurian, Devonian, and Carboniferous genera, but the *centronelliform* structure continues later, and is represented in the Trias by the genera *Juvarella* Bittner and *Nucleatula* (Zugmayer) Bittner.

It was at once suggested that interesting results would be obtained in studying the development of a spire-bearing brachiopod, and, as the earliest species more clearly show their phylogeny in their ontogeny, the ancient genus *Zygospira* was selected. Very complete material was accessible, collected by the writers from the Trenton of Minnesota and Kentucky, so that series of specimens were assembled representing all stages of growth from specimens .8 mm. in length to mature size. They were prepared to show their brachial supports, and it is clearly demonstrated that the primitive arm support in *Zygospira* is a terebratuloid loop having a *Centronella*-like form, which undergoes several modifications before the growth of the spiral lamellæ, and thus in so far resembling the development of *Diclasma*.

These results threw doubt on a number of Lower and Upper Silurian species described as having recurved loops and previously referred to the higher terebratuloid genera *Macandreria* or *Waldheimia*. The shells are impunctate, while *Rensselæria* and *Centronella* are distinctly punctate, like all other well-known terebratulæ. Upon investigation, it has been ascertained by Hall and Clarke and the authors that the species which have been referred to *Hallina* and *Macandreria* from the Silurian are spire-bearing forms, and therefore do not belong to the Ancylobrachia.

Fischer and Ehlert have called attention to a number of recent species which have been erroneously based upon the immature stages of higher species, and in the Terebratellidæ it is evident that great uncertainty must exist in the identification of specimens not fully adult. Now, finding that Paleozoic genera

of both loop and spire-bearing stocks (Ancylobrachia and Helicopegmata) in the adolescent period likewise pass through metamorphoses representing the structures of other genera and even other suborders, it is manifest that species cannot be referred to their proper genera nor genera correctly defined unless the individuals studied are adult and their characters constant for a definite period of time.

Development of the Loop in Dielasma turgida.

The earliest stage thus far observed was found in a specimen a little over four millimeters in length (plate x, fig. 1). The loop at this time is composed of two broad descending lamellæ, which begin at the ends of the crura and extend forward, curving ventrally until they unite in the median line, forming an angular ridge, acuminate in front. As previously mentioned, this structure is very similar to that of *Centronella*, and this stage is therefore called the *centronelliform* stage.

The first change in the form of the loop is brought about by a resorption of the pointed anterior portion, so that the outline is reëntrant in front (fig. 2). Further resorption in the same manner results in the production of two posteriorly directed branches, as shown in fig. 3. This form may be considered as an early immature *Dielasma* loop, as subsequent growth does not materially modify its general characters.

The adult loop, represented in figs. 4–6, differs from the early *Dielasma* stage chiefly in the divergence of the descending branches.

In the *centronelliform* stage the lamellæ converge, and the loop extends half the length of the shell. Both of these relations gradually alter until, in the early *Dielasma* stage, the descending branches are nearly parallel, the loop extends less than half the length, and, finally, when mature, the descending branches diverge and the loop is two-fifths the length of the dorsal valve.

The natural inferences to be drawn from the development of the loop in *Dielasma* are, that *Centronella* represents a larval or immature condition of the higher genera, and that the *centronelloid* loop is the primitive type in the Terebratulidæ. Therefore, as *Centronella* and the closely related genus *Rensselæria* are the only early punctate terebratuloids known, and as they have the primitive type of loop, there arises the question of the val-

idity of the Upper and Lower Silurian species with recurved loops, referred to *Waldheimia* and *Hallina*.

Hall and Clarke (Pal. N. Y., vol. VIII, part ii, pp. 147–153, not yet published) describe and figure the brachial supports in *Hallina*, showing that both *H. nicoletti*, Winchell and Schuchert and *H. saffordi*, W. and S. are provided with short spires of about one volution, connected by a transverse band, as in *Zygospira*. In removing the ventral valve and exposing the loop from that side, as is often done, the short spiral lamellæ have been overlooked. Similar observations have been made by the present writers, so that the systematic position of these forms is now established.

Specimens of *Waldheimia bicarinata* Angelin, from the Upper Silurian of Gotland, were also examined. They were found to possess well-defined spiral cones, and in other respects agreed with the diagnosis of *Dayia*. These facts indicate that the specimens described by Davidson as *Waldheimia mawii* (Fossil Brachiopoda, Supp. vol. IV, part v, pl. iv, figs. 1–3) are the young of *Dayia navicula* Sowerby, sp. (*ibid.*, pl. v, figs. 1–4).

Development of the brachial Supports in Zygospira recurvirostra.

The smallest specimen in which the internal structure was observed measures about 1.33 mm. in length (plate x, figs. 7, 8). The brachial supports consist of two straight, ventrally concave, primary lamellæ, rapidly increasing in width from the thin crural plates to near the center of the valve, where they unite, forming a plate with a central angular ridge. The anterior end of the plate is pointed as in *Centronella*.

In a specimen about 2 mm. in length (figs. 9, 10), the primary lamellæ are practically of the same form as in the preceding, but much of the original central portion of the loop has been resorbed, so that the lamellæ are connected by a short but comparatively wide, ventrally arched, transverse band. The lamellæ, or descending branches, are also more spreading anteriorly, and there is a slight deflection at the crural points, which becomes more and more pronounced as growth progresses.

In the next stage (fig. 11), which has a length of 2.33 mm., the descending branches are more diverging, and the transverse band is longer and more broadly excavated in front.

The succeeding stages here described are based upon material

derived from near the top of the Trenton, where the specimens of this species are usually larger and more transverse than those from near the base of the Trenton, which is the horizon of the specimens illustrated in figs. 7–11. Therefore, when the loop in fig. 9 is compared with that of fig. 12, it is seen that the latter is much the wider, from the greater size and breath of the shell, which has at this stage a length of 3.33 mm., while the former is but 2 mm. long. The loop in fig. 12 is somewhat more advanced than in fig. 9, the transverse band being narrower and slightly elevated posteriorly, some resorption having taken place along the inner edges of the primary lamellæ. Further resorption in same direction produces the brachial support illustrated in fig. 14. This form of loop in *Z. nicoletti*, *Z. saffordi*, and *Z. recurrirostra* from the lowest Trenton is retained to maturity. However, in specimens of *Z. recurrirostra* from the upper Trenton the posteriorly curved, transverse band is not a mature feature, since it becomes changed into the form represented in fig. 15. In previous stages the transverse band is ventrally arched, but it now bends dorsally, and remains so during subsequent growth until near maturity, when the sinus of the dorsal valve causes it to assume a sigmoid curve.

The spirals next begin to develop (figs. 16 and 17) as two slender converging lamellæ, curving toward the ventral valve and originating from the outer pointed ends of the loop. These lamellæ then incurve dorsally and laterally to a point just posterior to the transverse band, forming the first volution of a spiral (fig. 18). In this manner further growth and elongation of the lamellæ continue until maturity is attained, when there are about three volutions in each spiral cone (fig. 20). The calcareous brachial supports occupy about the same relative space in the shell cavity in all stages of growth.

Observations and Correlations.

Zygospira is the earliest spire-bearing genus known, as it is found in the Birdseye limestone of the Trenton period. It is of considerable interest, therefore, to study the development of the spirals. From the ontogeny, it is shown that the brachial supports in *Zygospira* begin as a loop greatly resembling that of Devonian *Centronella*. Moreover, the loop passes through a series of metamorphoses before the spirals make their appearance.

The most ancient species are *Z. nicoletti* and *Z. saffordi*, small semiplicate forms, in which the spirals are very rudimentary, consisting of about one volution. In the same geological horizon occurs *Z. recurvirostra*, having from two to two and one-half turns of the lamellæ in each spiral. The same species from the upper Trenton has three volutions, while in *Z. modesta* of the middle Lorraine there are from four to five whorls (fig. 25). In *Z. headi* (fig. 24), a large globose finely striated species of the upper Lorraine, there are six whorls to a cone. The geological history, therefore, shows a gradual increase of from one to six turns of the lamellæ in each spiral.

The transverse band connecting the primary lamellæ also undergoes a series of changes. It has been shown that the centronelloid loop (fig. 7) passes into one having the lamellæ joined by a posteriorly directed, transverse band (fig. 14). This form of loop is retained as a mature feature in the brachia of *Z. nicoletti*, *Z. saffordi*, and in the lower Trenton varieties of *Z. recurvirostra*. Passing to the specimens of the latter species, which are geologically later, the band no longer joins the lamellæ as far anteriorly as in the older variety (fig. 20). The point of connection in *Z. modesta* is variable (figs. 25 and 26), but is usually more posterior than in *Z. recurvirostra*, while in *Z. headi* it is manifestly more posterior than in any of the older species of *Zygospira*. The transverse band is now no longer arched backward, but is just the reverse (fig. 24), while its position is progressively more and more posterior, and the loop is gradually shortened before the spirals make their appearance. The gradual increase in the number of the whorls in each spiral and the recession of the transverse band have gone on together.*

The family Atrypidæ includes the genera *Zygospira*, *Glassia*, *Calospira*, *Anoplotheca*, *Atrypa*, and *Dayia*. It is easily distinguished from all other families comprised in the suborder Helicopegmata, since the spirals are between the first descending branches of the lamellæ, while in the Spiriferidæ, Nucleospiridæ, and Athyridæ the primary lamellæ are between the spirals.

The gradual increase in the number of whorls in the spirals and the pushing backward of the transverse band in the Atrypidæ is carried farthest in the species of *Atrypa*. In *Calospira*

*The extreme anterior position of the transverse band in *Z. recurvirostra* is therefore of no more than specific value, and on this account *Amazyga* Davidson cannot well be separated from *Zygospira*.

barrandei and *C. marginalis* the brachial supports, as worked out by Davidson and Glass, consist of about five volutions, and are similar to those of *Zygospira*, except that the transverse band is more posterior, since it originates near the ends of the crura. This mature condition of *Calospira* is seen to be a young condition of *Atrypa* (Davidson), but, as the spirals are more loosely coiled and the transverse band always continuous, this genus should be regarded as valid in the evolution from *Zygospira* to *Atrypa*. In mature *Atrypa reticularis* from the Upper Silurian, there may be as many as sixteen volutions in each spiral cone (Davidson), but more often the number is smaller. The transverse band in this species during its young stages is continuous, but in the adult condition it seems to be usually disunited in the middle. This feature becomes a distinct adult character in the Devonian specimens, which also have a greater number of whorls in the spirals, as shown in a Chemung specimen of this species in Yale University Museum, having twenty-four turns of the lamellæ in each spiral.

The ontogeny and phylogeny of the species of *Zygospira* indicate strongly that the *Atrypidæ* had its origin in a form with a centronelloid loop. A further natural conclusion from the same evidence is that the Ancylobrachia are older and more primitive than the Helicopegmata.

Explanation of Plate X.

Diclasma turgida.

Figure 1.—The *centronelliform* stage of the loop; ventral view. × 6.
2.—A later stage, showing the resorption of the anterior portion of the loop. × 6.
3.—Early *Diclasma* stage, produced by further resorption of the centronelloid loop. × 6.
4.—Loop and crural plates of mature specimen. × 6.
5.—Profile of the connecting band. × 6.
6.—Side view of the loop, crura, and septum. × 6. St. Louis group, *Kentucky*.

Zygospira recurvirostra.

Figure 7.—*Centronelliform* stage of the loop. × 12.
8.—Profile of same. × 12.
9.—A later stage; showing partial resorption of loop in front and greater divergence of descending branches. × 12.
10.—The same; profile. × 12.

Figure 11.—A little more advanced stage, showing increased length of connecting band. × 12. Specimens figures 7–11 are from the Trenton shales, *St. Paul, Minnesota.*

12.—A looped stage, with broad, curved, descending branches and more slender transverse band. × 6.

13.—The same; profile. × 6.

14.—A later stage, showing more slender loop. × 6.

15.—A specimen showing curved, diverging, descending branches, long transverse band, and two projections of the lamellæ, which are the beginning of the spiral cones. × 6.

16.—A subsequent stage in which the lamellæ are more extended and ventrally and inwardly curved. × 6.

17.—The same; profile. × 6.

18.—A young individual in which there are about one and one-half turns to each spiral. × 6.

19.—The same; profile. × 6.

20.—The brachial supports in a mature specimen. × 6. The specimens figures 12–20 are from the top of the Trenton, *Frankfort, Kentucky.*

21.—The spirals and loop in a Canadian specimen of (*Anazyga* —) *Zygospira recurvirostra.* (After Davidson.) × 3.

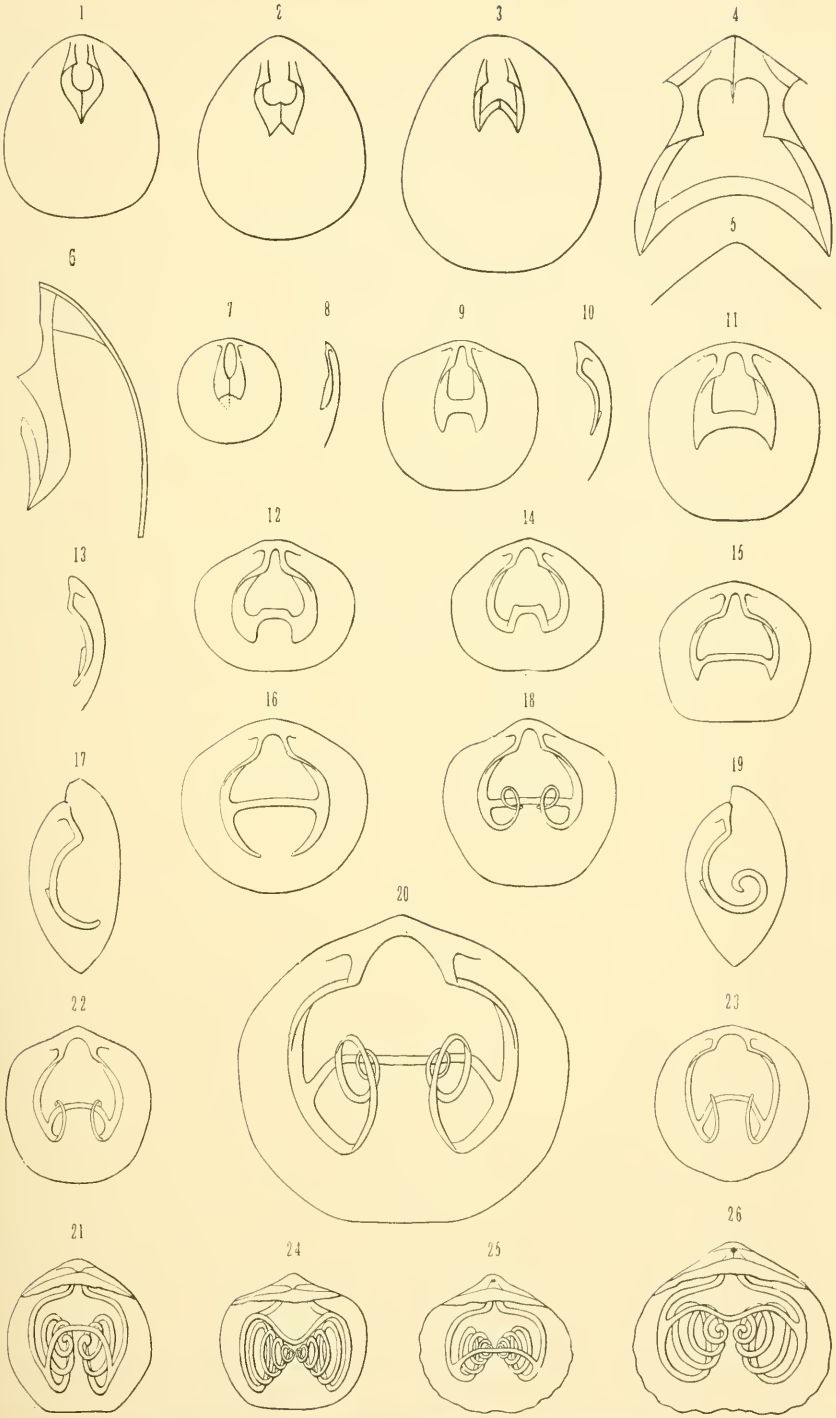
22.—The spirals and loop in (*Hallina* —) *Zygospira safford*i W. and S. Trenton, *Tennessee.* × 6.

23.—The spirals and loop in (*Hallina* —) *Zygospira nicolletti* W. and S. Trenton, *Minnesota.* × 6.

24.—The spirals and loop in *Zygospira headi* Billings. (After Hall.) × 2.

25.—The spirals and loop in *Zygospira modesta* Say. (After Hall.) × $2\frac{1}{2}$.

26.—The same. (After Davidson.) × $3\frac{1}{2}$.



Brachial supports in Dielasma and Zygospira.

ON THE DEVELOPMENT OF THE SHELL OF *ZYGOSPIRA RECURVIROSTRA*.

BY CHARLES SCHUCHERT.

The material showing the ontogeny of the shell in *Z. recurvirostra* was gathered from some blue-green shales on St. Anthony hill, a suburb of St. Paul, Minnesota. This horizon is equivalent to the lower Trenton of New York. Some of the associated brachiopods are *Orthis testudinaria*, *O. meedsi*, *Plectambonites sericea*, *Strophomena scofieldi*, *Clitambonites diversa*, etc.

The youngest specimen observed (plate xi, fig. 1) has a length of .8 mm., and is elongate subtriangular in outline, biconvex, with the ventral valve a little the deeper; ventral beak acuminate, inclined posteriorly at an angle of about 45° to the plane of the valves; delthyrium triangular, as wide as long and devoid of deltidial plates. In the apical portion there is a short concave plate continuous with the walls of the delthyrium, but apparently not attached to the rostral cavity. The fold and sinus are faintly developed, becoming obsolete at about the center of the shell and are without plications. In other individuals of about the same size the sinus is occupied by three short plications and the ventral fold by two. In specimens of a somewhat larger growth these primitive plications are rapidly followed by a number of new ones along the entire anterior margin. The size of the shell at which they begin to develop is variable (compare figs. 2–5), being the earliest in the narrow depressed individuals (fig. 3) and latest in the rounder and more convex specimens (fig. 4). New plications are rarely interpolated, their number being increased as growth proceeds by the addition of others along the lateral margins of both valves. The plications remain simple throughout.

The smooth nepiastic stage gradually grows more and more rotund and subquadrangular in outline, and at maturity is plicated to the apex of the shell. The ventral beak, which is at first slightly recumbent (fig. 1*a*), becomes erect, and finally is strongly incurved over the dorsal umbo (fig. 9*a*). The large

open delthyrium is gradually reduced in size by the introduction of deltidial plates which grow inwardly from the walls of the fissure, being wider anteriorly where they join, leaving in the apex an oval pedicle opening. As the beak incurves these plates become larger, stronger, and anchylosed along the median line, but at maturity are nearly completely hidden by the dorsal umbo. The pedicle opening at maturity (fig. 9) is through the acutely convex portion of the ventral umbo, and is comparatively smaller in size than during previous stages.

Growth Stages.—A well-preserved specimen of about 1.5 mm. length (fig. 10), shows three distinct stages of growth before the introduction of the plicated or specific period: *a*, the initial shell or protegulum, with both cardinal lines arched; *b*, a broad, oval stage, in which the ventral hinge areas on each side of the delthyrium first appear, followed by *c*, a subcircular form, with the beginning of the fold and sinus. It is either during stage *c* or *b* or both that the concave plate in the apex of the delthyrium is developed. During the next or fourth stage the first specific characters begin to appear, as shown by the plications, and also the first stage of the calcareous brachial supports.

Observations and Correlations.

The first or initial shell in *Zygospira*, as in other brachiopods, is the protegulum, which has been compared with adult *Paterina* of the Lower Primordial. In many inarticulate brachiopods it is known that the protegulum is followed by a nearly round *Obolella*-like inarticulate stage, but in all rostrate articulate species in which the second stage has been observed there appears the first articulation of the valves. The fold and sinus, along with a few rudimentary plications, are introduced during the third stage of *Zygospira*. This form of shell much resembles some primordial species which have been provisionally referred to *Camarella*. With but slight modifications in the convexity of the valves and the greater or less prominence of the fold and sinus, this form is repeated in a number of early Paleozoic genera of the suborders *Trullacea* and *Rostracea*, as primordial *Camarella* and many species of *Pentamerus*, *Zygospira nicoletti*, *Camarella bisculata*, *Dayia*, and the so-called *Waldheimias* of the Upper Silurian. It is therefore impossible to refer with certainty on the basis of external character alone any Lower Silurian brachi-

opod of this form to any family of the Rostracea or to any rostrate family of the Trulacea. The presence or absence of deltidial plates at maturity, however, at once indicates the subordinal position of any rostrate species. If the rudimentary concave plate in the apex of the delthyrial cavity of nepiastic *Zygospira* has any phylogenetic significance, it shows that those families having deltidial plates and no spondylium, the Rostracea, had their origin in the Trullacea, a suborder in which the concave plate or spondylium is functional as a muscular fulcrum. This has already been inferred to be the case on other grounds, as geological occurrence and complexity of structure. A plate similar to that in nepiastic *Zygospira* exists in *Gurynia*, *Cistella*, *Atretia*, and *Terebratulina*.

At the beginning of the fourth shell stage of *Z. recurvirostra* the species is recognizable as belonging to the suborder Rostracea and apparently most closely related to the Rhynchonellidæ. The calcareous brachial supports first appear in a specimen about 1.33 mm. in length. The species is then referable to the Ancylobrachia, having a loop very much like that of *Centronella*. This loop then passes through a series of metamorphoses, acquiring spirals when the shell is about 3 mm. in length.

The mature exterior characters of the more prominent species of *Zygospira* will next be considered. *Z. nicoletti* (figs. 11, 11*a*, 12, 12*a*), one of the oldest species, retains many of the characters of the earliest period of the fourth growth-stage of *Z. recurvirostra*, and therefore more nearly resembles in form the primitive stock which gave rise to *Zygospira*. In *Z. saffordi* (figs. 13, 13*a*) the plications are more numerous than in *Z. nicoletti*, but reach the posterior third of the valves, and the shell is also more convex. *Z. recurvirostra* is larger, more convex, with a greater number of plications, which originate at the apex of the valves, and the ventral beak is more strongly incurved than in the species mentioned. From *Z. recurvirostra* one line leads through *Z. uphami* and *Z. erratica* to *Z. headi*, comprising a group which continues to increase in size, gibbosity, striation, and in the obsolescence of the fold and sinus. In another phylum characterized by *Z. deflecta*, *Z. modesta*, *Z. cincinnatiensis*, and *Z. kentuckyensis*, the plications do increase in size but not in number, while the inconspicuous fold and sinus of *Z. recurvirostra* is gradually developed more and more strongly, so that when the extremes of both lines are compared (*Z. headi* and *Z. kentuckyensis*) very

dissimilar exteriors are seen to have resulted from the same stock. *Zygospira* attained the greatest development in the Lorraine group of the Ohio valley. The species are usually very abundant in individuals, often forming groups several inches in diameter.

EXPLANATION OF PLATE XI.

Figure 1.—Dorsal view of the smallest specimen observed of *Zygospira recurvirostra* Hall. The fold and sinus are just visible along the anterior margin of the shell. × 12.

2.—A later stage, where the deltidial plates have begun to develop. × 12.

3.—A specimen in which the plications are developed unusually early. × 12.

4.—A specimen of larger growth than figure 3, in which the plications are slow in developing. × 12.

5–8.—Different individuals to show the progression of growth in the deltidial plates and the extent of the plications over the umbones. × 12.

9.—A mature example. The pedicle foramen is posterior to the deltidial plates, encroaching on the umbone of the ventral valve. × 6.

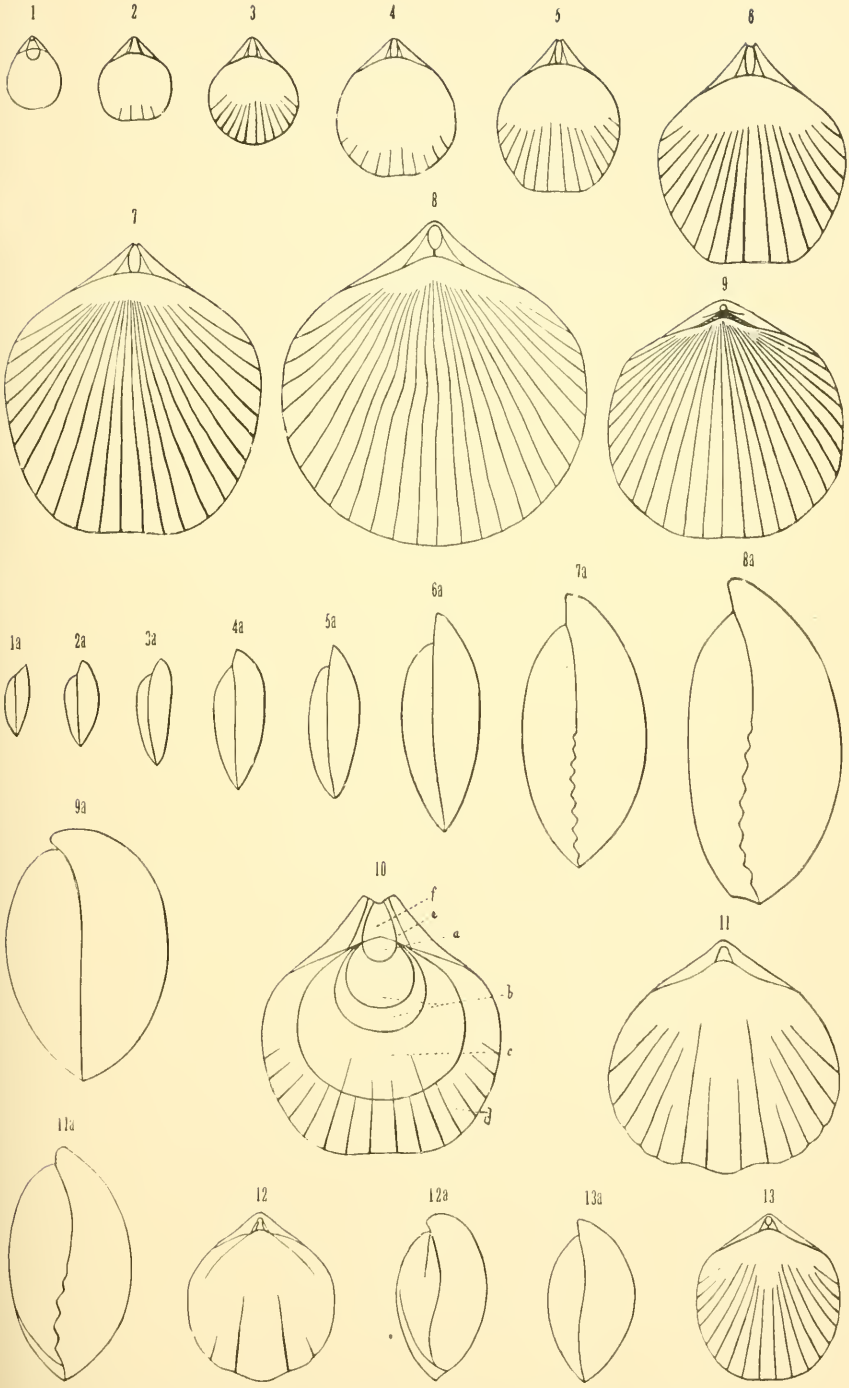
1*a*–9*a*.—A series of profiles of the specimens, figures 1–9, respectively, showing the change in the convexity of the valves and the incurvature of the ventral beak.

10.—A specimen preserving the lines of growth very clearly, of which the stronger ones only are figured. The apex of the ventral beak has been worn away by abrasion and resorption by the pedicle. *a*, protegulum; *b*, the first articulate stage; *c*, the stage in which the fold and sinus are developed; *d*, the plicated stage; *e*, deltidial plates; *f*, pedicle opening. × 25.

11, 11*a*.—An unusually large specimen of (*Hallina* =) *Zygospira nicoletti* W. and S., in which a few plications are developed on each side of the fold and sinus. × 6.

12, 12*a*.—Dorsal and profile views of one of the types of (*Hallina* =) *Zygospira nicoletti* W. and S., the form most commonly observed. × 6.

13, 13*a*.—Dorsal and profile views of the type of (*Hallina* =) *Zygospira saffordi* W. and S. This species is closely related to *Z. recurvirostra*. × 6.



Development of the shell of Zygospira recurvirostra.

VOL. VIII, PP. 83-96 JULY 18, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

REDISCOVERY OF THE MEXICAN KANGAROO RAT, *DIPODOMYS PHILLIPSI* GRAY

BY C. HART MERRIAM, M. D.

WITH FIELD NOTES BY E. W. NELSON.

The first kangaroo rat known to naturalists was described by J. E. Gray, in 1841, under the name *Dipodomys phillipsi*.* Both species and genus were new, and were based on a single specimen presented to the British Museum by John Phillips on his return from Real del Monte, in the state of Hidalgo, Mexico, in the vicinity of which place it was supposed to have been obtained.† This specimen still remains unique, so far as authentic published records go, notwithstanding the fact that numerous museums in this country and Europe contain specimens labeled *D. phillipsi* which have been examined and treated as

*_Dipodomys phillipii_ Gray, Annals and Magazine Nat. Hist., VII, Aug., 1841, 522. In the original article the name was spelled *phillipii* by typographical error; it was corrected to *phillipsii* a few months later by the same author. (Am. Jour. Sci., XLII, 1842, 335.)

† Real del Monte is in the mountains at the extreme north end of the Valley of Mexico, about 50 miles northeast of the City of Mexico.

true *phillipsi* by nearly all writers on the genus during the past half century.

In studying a large series of kangaroo rats from Texas, New Mexico, Arizona, and California several years ago I was surprised to find that none of them conformed with the original description or with Audubon and Bachman's plate and measurements taken from the type specimen in the British Museum. It became apparent therefore that true *Dipodomys phillipsi* was not represented in the extensive collections examined, and probably was not an inhabitant of any part of the United States. Every available means was used to secure specimens from the supposed type locality, but without success. Letters were written in both English and Spanish to Mexican officials in Real del Monte describing the animal and offering a reward for a specimen, and later an experienced mammal collector was sent to the place, but with no better result. Finally Mr. E. W. Nelson, who has caught hundreds of kangaroo rats in various parts of the United States and Mexico and is thoroughly familiar not only with the habits of the animals but also with the kind of country inhabited by them, was requested to visit the region, in connection with his work for the United States Department of Agriculture. The result is a series of 67 handsomely prepared skins and skulls and several complete skeletons of the long lost *Dipodomys phillipsi*. Hence, after a lapse of more than fifty years, it is now possible for the first time to redefine the type of the genus and to differentiate the species from others with which it has been persistently confounded. Before doing this, however, it seems desirable to put on record with some detail the facts connected with its rediscovery and distribution.

Notes on a Search for Duplicate Types of Dipodomys phillipsi.

In response to my request, Mr. Nelson has contributed the following interesting account of his search for this species:

"After securing specimens of *Dipodomys phillipsi* in the Valley of Mexico, at Tlalpam, Ajusco, and Amecameca in December, 1892, and February, 1893, I finally set out to try and obtain specimens nearer Real del Monte, the supposed type locality. A long and careful search in the vicinity of Tula, in Hidalgo, just north of the valley, failed to discover it or any allied species. From that point to Pachuca, along the extreme northern border of the valley, the country presented the same hard, rocky, and unsuitable character found at Tula. Pachuca is situated at the extreme

northeastern point of the Valley of Mexico, at the base of the Sierra de Pachuca, the latter forming the limit of the valley in this direction. At an altitude of about 9,000 feet, and about three or four miles in a direct line higher up in these mountains, lies the mining town of Real del Monte, the reputed type locality. The mountains are almost wholly composed of porphyry, with only a very scanty coating in places of a hard, clayey soil. A short visit to this locality was enough to show very conclusively that no species of this group had ever been taken in its immediate vicinity. A visit to the northern slope of the mountains near El Chico showed it to possess the same character.

"The next effort was made in the forlorn hope of finding the species about the border of the valley, at the base of the mountains, near Pachuca. A careful search of this vicinity for some miles in various directions failed to discover any sign of kangaroo rats or, indeed, any sufficient area of suitable ground. A trip was then made to the village of San Augustin, 18 miles south of Pachuca, in the Valley of Mexico, and this also resulted in finding the same rocky hills and hard clayey bottoms that prevail about the northern end of the valley.

"Giving up all hope of finding the species near Pachuca or Real del Monte—the alleged type locality—I decided to make another search for it at Irolo, which lies a little more than 25 miles south of Pachuca, in Hidalgo, and just east of the low divide which borders the Valley of Mexico on the east between the Sierra de Pachuca and the northern end of the Sierra Nevada de Iztaccihuatl. The course of the Vera Cruz or Mexican railway, on which I traveled, at first kept to the south near the west side of the divide. Some six miles out of Pachuca we passed over a narrow belt of softer soil than usual here, and I had hasty glimpses of several burrows among the maguey plants that I was quite certain belonged to some species of kangaroo rat. The road then left the divide and swung out into the Valley of Mexico, and the soil again became a hard clay. From the station of Ometusco, just within the Valley of Mexico, the road leads east for a few miles over a low dividing ridge to Irolo. About the latter place and away to the northward, toward the mountains of Pachuca, the bases of the low hills and ridges show pale yellow shades such as sandy deposits would give. A short search about the base of the hills near Irolo showed that areas of sandy and loose soil did in fact exist there.

"Further search showed that these areas of soft soil were occupied by kangaroo rats, which when captured, however, proved to be a 5-toed *Perodipus* instead of a 4-toed *Dipodomys*. No trace of any other species could be found, but the *Perodipus* was abundant.

"From the fact that the belt of country in which this species occurs at Irolo extends directly toward the point where I saw the signs on the road from Pachuca, with less than twenty miles intervening and a divide of not over 250 feet, I feel fully justified in assuming that the animals whose burrows were seen near Pachuca are a colony of the same species as that found at Irolo, namely, a *Perodipus*.

"On the other hand, the city of Tlalpam was the capital of the state of Mexico from 1828 to 1830, and from a much earlier period has been one of the important towns of the Valley of Mexico. This being the case, the abundance of *Dipodomys* in the sandy land at the very border of the town suggests the probability that a specimen taken there by an early traveler may have been the one brought to London by Mr. Phillips of Real del Monte, the erroneous reference arising from the notorious carelessness of the early collectors in labeling specimens."*

It should be added that Tlalpam is only about 60 miles from Real del Monte, and should be remembered that Gray did not say that his specimen came from Real del Monte, but merely that it was sent to the British Museum by "Mr. John Phillips, who has lately returned from Real del Monte"—quite another matter. The probability is exceedingly great that the specimen was not labeled at all before it entered the British Museum.

Geographic Distribution.

Mr. Nelson first found *Dipodomys phillipsi* at the extreme southern end of the Valley of Mexico and on the adjacent mountain slopes, where 28 specimens were obtained. Concerning its occurrence in this region he writes:

"These kangaroo rats occur in the bottom of the valley near Tlalpam, D. F., at an altitude of 7,500 feet, and at the eastern base of the main peak of Ajusco, near the village of the same name, at an altitude of something over 10,000 feet. Still further to the south, on the extreme border of the state of Mexico, adjoining Morelos, they were noted close to the peak of Huitzilac, near the Cruz del Marquez, at an altitude of 9,000 feet. They were also taken at the western base of Mt. Popocatapetl, near the village of Amecameca, at an altitude of about 8,300 feet. The peak of Huitzilac lies about 20 miles south of Tlalpam, and Amecameca is 28 miles east of the peak of Ajusco, thus giving the species a known range of less than 20 by 30 miles in this district.

"The animals were far more numerous near Tlalpam than elsewhere. This place is 9 miles south of the City of Mexico, at the extreme southern border of the valley, just where the first slopes of the Sierra de

* In continuing my work to the eastward I found it necessary to visit the city of Puebla. There I learned that the State College had a small museum, which I visited. One of the first things that met my eye was a *Dipodomys phillipsi* labeled as coming from *Ojo de Agua, Puebla*. Leaving the city, my route took me first into Tlaxcala and thence to eastern Puebla, in both of which districts I found the species abundant, as detailed elsewhere in this paper.

Ajusco begin to form the mountain rim on that side of the basin. Lying just west of Tlalpam is a great lava bed, known as the *Pedregal*, which descends from the northern base of the peak of Ajusco and reaches down the slope and out along the southwestern border of the valley. The peak of Ajusco, rising to an altitude of 12,600 feet, lies about 9 miles in a southwesterly direction from Tlalpam. Commencing near the eastern base of this peak and following down the eastern border of the lava bed to the bottom of the valley at Tlalpam is a bed of fine, grayish volcanic ashes or sand. Originally this deposit of sand did not reach the bottom of the valley, but the heavy summer rains gradually washed it down until it is now spread for a mile or two out over the bottom, at the base of the hills extending east from Tlalpam. In this bed of fine, sandy soil, beginning almost with the last houses of the town, these kangaroo rats are very abundant. The ground occupied by them at Ajusco, Huitzilac, and Amecameca was once covered with pine timber, but is now used as corn or grain fields, and it is altogether likely that the distribution of the species in all of these localities from the border of the Valley of Mexico followed the subjection of the land to cultivation. At the present time, although there are large areas of apparently suitable land, its distribution is local and restricted to comparatively small districts."

At a later date Mr. Nelson found *Dipodomys phillipsi* on the plains of Puebla and thence northerly into eastern Tlaxcala and western Vera Cruz. Concerning its occurrence in this region he writes:

"The species was not encountered again until I reached the state of Tlaxcala. There, in the eastern half of the state, about the northern and eastern base of the Cerro de Malinche and the towns of Huamantla and San Marcos, it is common. Extending thence easterly along the same sandy plain into the state of Puebla, it is also very numerous.

"In this latter state the species reaches its extreme southeastern limit near the towns of Cañada Morelos and Esperanza. To the north of these localities it is abundant about the towns of San Adres, Chalchicomula, and up the adjacent western base of Mount Orizaba to an altitude of 9,000 feet. From these points it ranges across to Ojo de Agua and San Juan de los Llanos, in the same state. To the northeast its extreme limit is found about the northern and western base of the Cofre de Perote, a little east of the town of Perote, in the state of Vera Cruz. This gives the species a known range over parts of four states. It occupies the extreme southern end of the Mexican table-lands, and is therefore the extreme southern representative of the genus.

"So far as my observations have extended, this species is confined strictly to the areas of volcanic sand produced by two volcanic centers: *first*, the sandy belt lying between Mount Popocatapetl and the Cerro de Ajusco, some thirty miles in a westerly direction from the first-named peak, and all within the State of Mexico; *second*, the much larger district having its

eastern border along the volcanic range from Mount Orizaba to the Cofre de Perote, and extending thence west to the eastern base of Mount Popocatapetl, crossing a small corner of Vera Cruz and all of the states of Puebla and Tlaxcala. Since the sandy plain of southern Tlaxcala and central and western Puebla as far as the eastern base of Popocatapetl is a continuation of the same character of country as that in which I have found the species in adjacent parts of these states, I have no doubt that further work will show it to be equally common in these unexplored districts. That the species ranges from Puebla and Tlaxcala northwesterly toward its reputed type locality in the Sierra de Pachuca is improbable, since a high pine-covered area separates the two districts.

"The presence of this species in Puebla and Tlaxcala adds considerably to the uncertainty attending the probable source of the type specimen. While Tlalpam was a well-known locality of early days in this country, it is to be taken in consideration that the regular highway (stage road) from Vera Cruz to the City of Mexico passed Perote and traversed a hundred miles of country where this species is very common. The vertical range of this species lies between 7,400 and 10,000 feet, but by far the greater number of individuals are found between 7,500 and 8,500 feet. Its center of abundance is in southeastern Tlaxcala and adjacent parts of eastern Puebla. Its extreme upper range, both at Ajusco and Mount Orizaba, is due to the animals following cleared fields up into the pines from their original lower range on the plains."

Habits.

Respecting the habits of *Dipodomys phillipsi* Mr. Nelson contributes the following, which, unless the contrary is stated, relates to the neighborhood of Tlalpam:

"Their little trails were to be seen after a calm night crossing the sand in every direction, forming in many places a perfect network. Each animal occupies a burrow having as a rule a single entrance, dug in the bare, open field. The holes enter the ground at a slight angle, and each has a shallow trough-like depression leading out from it for a few inches, as is customary with most members of the group. Ordinarily the trail leaving the burrow forks, forming a Y very close to the entrance, and each branch trail leads away across the sandy soil to a neighboring hole, or to a distance where it becomes lost among the scanty herbage, where the owner finds its forage of seeds and small succulent leaves. Here and there little cone-shaped pits, an inch or two deep, show where the inhabitants have dug up little plants or hidden seeds.

"When captured the animals frequently had their cheek pouches full of seeds and small green leaves or young plants. Judging from what I noted in this way, it was evident that quite a variety of small plants contribute to their food supply. At the four localities where they were found they were located in old grain fields and their burrows and habits appeared to

be the same. In no instance was a group of holes noted, and it was rare to find two entrances to the same burrow.

"Except at Tlalpam, they were not found in considerable numbers in the Valley of Mexico, and were scattered. Wherever found they were always in very loose, sandy soil. At Tlalpam their burrows appeared to be shared by the little yellow pocket mouse (*Perognathus*), which was nearly as common as the *Dipodomys*.

"As usual in this group, these animals are strictly nocturnal, and judging from the number of tracks, they must be very active during calm nights, even when the temperature is some degrees below freezing. For one or two nights during a severe storm they do not venture out, but if the storm continues longer they forage enough to procure food. At Ajusco at rare intervals a foot or two of snow covers their haunts, and cold storms are common. Elsewhere in their range sharp frosts are common during the winter months.

"The preceding notes concerning the habits of this species, although written with particular reference to the south end of the Valley of Mexico, apply equally well to other parts of its range. In the eastern part of its range it frequents the same open sandy fields, but many of the holes were also found at the bottom of shallow ditches entering the ground at the foot of the low bank at the sides. Others were found similarly situated along the sides of small arroyos. In one field above Chalchicomula the holes entered the ground almost perpendicularly for five or six inches before sloping away at the usual slight angle. This was due, however, to the fact that the very loose sandy character of the surface soil made it impossible to start a hole in at the usual angle."

Identity of Nelson's Specimens with Dipodomys phillipsi Gray.

Apart from the geographic proximity of Real del Monte to the region where Mr. Nelson obtained his specimens, and wholly independent of the question as to whether or not the animals whose burrows were observed 6 miles south of Pachuca belong to the same species, or to the genus *Perodipus*, the specimens themselves afford positive proof that they are the species described by Gray as *Dipodomys phillipsi*, as may be seen from Gray's original and very circumstantial description, which is here reproduced entire:

"*A new Genus of Mexican Glirine Mammalia.*—Mr. John Phillips, who has lately returned from Real del Monte, Mexico, has, at the recommendation of Mr. John Taylor, sent to the British Museum the skins of some very rare and interesting birds, of a *Bassaris*, and of the new animal which I shall now proceed to describe. This animal is very interesting, as having all the external form and coloring of a *Gerboa*: and it is doubtless the American representative of that African genus, though differing from it very essentially in being provided, like some other American genera,

as *Saccophorus*, *Saccomys*, and *Heteromys*, with large cheek-pouches, which open externally on the side of the cheeks. I propose to call it

"*Dipodomys*.

"Body covered with soft hair. Head moderate, with large cheek-pouches opening externally on the side of the cheeks. Ears and eyes rather large; the fore-legs short; the hind tarsus long and slender; the hind feet very long; the soles covered with hair; toes 5-4. The tail much longer than the body, covered with rather short hair, and with a dilated brush at the end; the upper cutting teeth grooved in front. Grinders—(?)

"This genus differs from all those above cited in the tail being elongated and covered with hair, with a pencil at the ends like the *Gerboas*, and from *Saccomys* in the soles of the hind feet being hairy.

"*Dipodomys phillipii Gray*.

"Gray-brown, with longer black hairs; sides sandy; sides of the nose, spot near the base of the ears, band across the thigh and beneath, pure white; nose, spot at the base of the long black whiskers, and at the base of the tail, black; tail black-brown, with the band on each of its sides and tip white; penis ending in a long spine. Length: body and head, 5 inches; tail, 6½ inches; hind feet, 1½ inch.

"Inhab. Mexico, near Real del Monte. John Phillips, Esq." (J. E. Gray, Annals and Magazine of Natural History, vol. VII, No. 46, August, 1841, pp. 521–522.)

By a fortunate circumstance Gray's type specimen was figured by Audubon in his colored plate (No. CXXX), which plate has the additional merit of tallying with the description and also with the specimens collected by Mr. Nelson.*

The measurements given by Gray (and repeated by Audubon) are: Head and body, 5 inches; tail, 6½ inches; hind feet, 1½ inches. Converted into millimeters, the length of the tail is 165, and of the hind foot 38. The averages of these measurements in 54 specimens collected by Mr. Nelson are: Tail, 167.5; hind foot, 41. In several individuals the hind foot fell to 39 mm. Mr. Nelson's measurements were taken in the flesh, which accounts for the slight difference in the length of the hind foot.

* Audubon states: "Our drawing was made from a beautiful specimen in the British Museum, which was the first one brought under the notice of naturalists, and the original of Mr. Gray's description of this singular animal; it was procured near Real del Monte, in Mexico." (Quadrupeds of North America, vol. III, 1854, 140.)

In the light of the ample material collected by Mr. Nelson, the species may be redefined as follows:

Dipodomys phillipsi Gray.

Dipodomys phillipii Gray, Ann. and Mag. Nat. Hist., VII, 1841, 522. (Name spelled *phillipii* by typographical error and corrected to *D. phillipsii* by same author a few months later.—Am. Journ. Sci., XLII, 1842, 335.)

Macrocolus halticus A. Wagner, Wiegmann's Archiv für Naturgeschichte, 1846, 172–177 (from 'Mexico').

Dipodomys phillipsii Audubon and Bachman, Quadrupeds of North America, vol. III, 1854, plate (colored) CXXX (of Gray's type specimen), and pp. 137–140 in part.

NOTE.—The *D. phillipsi* of subsequent authors is composite and does not include this species at all.

Type Locality.—The Valley of Mexico, Mexico.

General Characters.—Tip of tail white; size, smallest of the species having this peculiarity (about equaling *D. merriami*, but tail longer); coloration very dark, resembling *D. californicus*.

Measurements.—Average of 23 adult specimens from Tlalpam and Ajusco, at the south end of the Valley of Mexico (measured in the flesh): Total length, 270 mm.; tail vertebræ, 168; hind foot, 41.

Color.—Upper parts sepia-brown, more or less suffused with ochraceous, and everywhere conspicuously mixed with black-tipped hairs; thigh patches large, becoming dusky, and forming a large black patch behind and on the sides of lower leg and ankle, reaching upper surface of heel; crescents at base of whiskers large, nearly black, and meeting across nose; eyelids black; supraorbital spot obscured; upper and lower tail stripes black, meeting along distal third, and succeeded by a short brush of pure white, usually measuring only 10 to 15 mm., thus being decidedly shorter than in any other white-tipped species.

Cranial Characters.—Skull slightly larger than *D. merriami*, but not so large as *D. californicus*. Viewed from above, the post-rostral portion of the cranium is subquadrate in shape, owing to the great breadth across the orbital bridges of the maxillaries, and the relatively slight development of the mastoids. The least interobital breadth of the frontals is greater than in any other species of the genus, equaling or exceeding the distance from the foramen magnum to the premolar, and considerably exceeding the length of the nasal bones. The tympanic capsule

is produced anteriorly beyond the plane of the adjoining part of the mastoid, a condition not found in any other species except *D. merriami*, from which it differs in shape, being narrower and having the greatest projection on the inferior surface, while that of *D. merriami* is bluntly rounded anteriorly. The inflated mastoids are both relatively and actually smaller than in any other species and are separated on top of the skull by at least 3 mm. The forks of the supra-occipital enclose a broadly oval interparietal. The top of the skull is considerably arched both antero-posteriorly and transversely, the highest point being the middle of the fronto-parietal suture. The mandible is rather light and slender, and the angular processes are less strongly developed than in any other member of the genus.

Geographic Distribution.—The Valley of Mexico and adjacent mountain slopes on the south, and the plains of Puebla from Cañada Morelos and Esperanza north to Huamantla, Tlaxcala, and Perote, Vera Cruz.

Faunal Position.—From Mr. Nelson's account of the haunts of this species it appears to be an inhabitant of the Transition Zone (or perhaps of both the Upper Sonoran and Transition), in which respect it agrees with the California species which it most closely resembles (*D. californicus*), and differs from all others of the genus—the others being Lower Sonoran.

Variations in Dipodomys phillipsi.

The area inhabited by *Dipodomys phillipsi* is so small that the characters of the species are very constant, as would be expected. In 28 specimens from Tlalpam and Ajusco the length of the white tip of the tail, beyond the black hairs that overlap its base, varies from 5 to 15 mm.

The dark facial crescents and connecting band across the nose vary somewhat in different specimens from the same locality, but average much broader and blacker in those from the plains of Puebla than from the Valley of Mexico.

The tail averages shortest in specimens from Perote, Vera Cruz (163.4 mm.), and longest in those from Huamantla, Tlaxcala (175 mm.).

TABLE OF AVERAGE MEASUREMENTS,* RATIOS, MAXIMA AND MINIMA, AND PERCENTAGES OF VARIATION BY LOCALITIES, IN *DIPODOMYS PHILLIPSI* GRAY.

Localities.	No. of specimens.	Averages.			Ratios.		Maxima and minima.						Percentages of variation from mean measurements.		
		Total length.	Tail vertebræ.	Hind foot.	Ratios to total length.		Total length.		Tail vertebræ.		Hind foot.		Total length.	Tail.	Hind foot.
					Tail vertebræ.	Hind foot.	Max.	Min.	Max.	Min.	Max.	Min.			
Tlalpam, D. F., Mexico.	23	270	168	41.1	62.3	15.2	285	254	180	156	43.5	39	11.4	14.2	12.1
Chalchicomula, Puebla.	30	273.1	168.8	41	61.8	15	291	257	182	158	43	39	12.4	14.2	9.7
Huamantla, Tlaxcala..	3	279.6	175	41	62.5	14.6	295	268	186	165	42	40	9.6	12	4.8
Perote, Vera Cruz.....	5	264.4	163.4	40.7	61.8	15.3	280	255	174	158	41.5	40	9.4	9.7	3.6

*All measurements in millimeters.

Remarks on the Accompanying Table.

The table on the preceding page is believed to possess certain advantages over the ordinary method of tabulating measurements of mammals. It presents to the eye in the brief space of four lines a summary of the average measurements, ratios, maxima and minima, and percentages of variation, by localities, of 61 specimens, instead of covering a number of pages with the detailed measurements of each individual.

The usual object of measuring zoölogical specimens is to ascertain one or more of the following facts: (1) the normal* size of the animal; (2) the proportions (or ratios) of some of its parts, and (3) the limits or extremes of variation in a large series of individuals (which may be expressed both in actual maximum and minimum measurements and in percentages of the normal). The accompanying table not only summarizes this information for each locality in a single line, but also, by bringing into sharp contrast corresponding data from different localities, shows the amount of geographic variation in the species. Tables of the ordinary sort may contain the material from which these important facts can be ascertained, but the labor of digging them out from the bewildering mass of figures in which they are buried is so great that it is rarely undertaken.

Note on Macrocolus halticus Wagner.

A word is necessary, perhaps, concerning the *Macrocolus halticus* of Wagner,† which has been a stumbling block to naturalists for many years, though its true position was correctly indicated by Baird thirty-five years ago. Baird's remarks were as follows: "Although Wagner expressly states that there were no external cheek pouches in his specimen, and that in consequence it could not belong to Gray's genus, *Dipodomys*, yet the coincidence in every other respect—skull, teeth, skeleton, and external form—is so very intimate as to render it almost certain that the

* The normal of any measurement is the average or mean of that measurement in a large series of adult individuals from the same locality. In preparing such tables care should be taken to exclude all immature and imperfect specimens.

† *Macrocolus halticus* A. Wagner, Wiegmann's Archiv. für Naturgeschichte, 1846, 172–177.

cheek pouches must have been overlooked, especially as we are particularly informed that the specimen was in very defective condition as preserved in alcohol. The species was probably identical with that described by Gray, viz: *D. phillipii*, which appears to be the one common in Mexico."* It should be borne in mind, however, that at the time Baird wrote (in 1857) all of the kangaroo rats were referred to *Dipodomys*, the genus *Perodipus* (containing the 5-toed species) not having been established until ten years later.† That Wagner's animal could not have been a *Perodipus* is clear from the statement that it had only 4 toes on the hind foot, and by other details of the original description. On the other hand, that it was a true 4-toed *Dipodomys* is shown by Wagner's original description, which includes a detailed account, with measurements of the skull and skeleton;‡ by his drawing of the skeleton (natural size), published a little later,§ and by his drawings of the teeth, contained in the supplement to Schreber's Säugthiere (tab. 239, E.).

The genus being disposed of, the species now comes up for determination. The fact that Baird referred it to *D. phillipsi* of Gray, in which he was followed by Coues, is of no weight, since both of these authors included under this head not only several very distinct species, but also species belonging to both genera. Nothing is known of the source of the specimen save that it came from Mexico. Three species of the genus are now known to inhabit Mexico, namely, *D. phillipsi*, *D. spectabilis*, and *D. merriami*. *D. spectabilis* may be at once eliminated because of its much larger size, leaving only *D. phillipsi* and *D. merriami* between which to choose. Wagner's measurements of the skull and skeleton give a total length of 269 mm. and a length of tail vertebræ of 168. His external measurements of the body and tail added together make a total of 279 mm., an excess of 10 mm. over the length of the skeleton, as usual when the body and tail are measured separately, the length of the body overlapping the point from which the tail measurement begins. Allowing

* Baird, Mammals of North America, 1857, 409.

† Fitzinger, Sitzungsber. math.-nat. classe, K. Akad. Wiss. Wien, LVI, 1867, 126.

‡ *Macrocolus halticus* A. Wagner, Wiegmann's Archiv. für Naturgeschichte, 1846, 172–177.

§ Beitrage zur Kenntniss der Säugethiere Amerikas, II Abth., 1848, 319 und 332, pl. VII (Abhandl. d. II, Cl. d. k. Ak. Wiss V, Bd. II).

1 mm. for the thickness of the skin over the end of the nose, the measurements given by Wagner for the skeleton of his *Macrocolus halticus* (converted into millimeters) are: Total length, 270; tail vertebræ, 168; hind foot, 39.5. The averages of 23 adult specimens of *Dipodomys phillipsi* collected in the Valley of Mexico by Mr. E. W. Nelson are: Total length, 270; tail vertebræ, 168; hind foot, 41.1, the agreement being surprising. The measurements and description of the skull and skeleton also agree with those of *D. phillipsi* and not with *D. merriami* or any other species. The number of tail vertebræ is stated by Wagner to be 31. In two skeletons from Tlalpam the number is 32. No other species of *Dipodomys* is known to have more than 29, and no species of *Perodipus* more than 28. Furthermore, if additional evidence is needed, the drawing of the skull shows conclusively (if even approximately correct) that the animal is *D. phillipsi*, the interorbital breadth of the frontals being considerably greater than in any other species, and the mastoids being only slightly developed for a *Dipodomys*, the consequent breadth of the cranium across the mastoids but slightly exceeding the breadth across the maxillary bridges of the orbits.

It has been shown by the process of elimination that Wagner's animal could not belong to any known species other than *Dipodomys phillipsi;* and it has been shown by direct comparison of his description with duplicate types of the latter species that it does agree with this species in every particular. It seems safe to infer, therefore, that *Macrocolus halticus* of Wagner is *Dipodomys phillipsi* of Gray.

Vol. VIII, pp. 97-108, pls. XII, XIII July 20, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

THE PALEONTOLOGY OF THE CRETACEOUS FORMATIONS OF TEXAS.

THE INVERTEBRATE FOSSILS OF THE CAPRINA LIMESTONE BEDS.

BY ROBERT T. HILL.

Contents.

Page.

I.—Stratigraphic Position of the Caprina Limestone Beds in the Comanche Series 97
II.—Characteristic Fossils 100
III.—Age of the Caprina Limestone Beds 104
IV.—Description of Species 105
V.—Plates 108

I.—Stratigraphic Position of the Caprina Limestone Beds in the Comanche Series.

About midway in the column composing the Comanche series or Lower Cretaceous of Texas, and constituting the uppermost member of the Fredericksburg division (Comanche Peak group of Shumard in part), there is a peculiar group of strata known as the Caprina limestone of Shumard.*

Dr. Shumard placed the bed in the Upper Cretaceous, at the very top of the whole of the fifteen or more subdivisions of the

* First Annual Report Texas State Geological Survey, Austin, 1880–'88, pp. 124–126.

two great formations of Texas, instead of in the middle of the lower series, where it belongs. His original description of it is as follows:

Caprina Limestone.—This is the uppermost recognized member of the series and, although of no great thickness, has a somewhat extended geographical range. It is a yellowish-white limestone, sometimes of a finely granular texture and sometimes made up of rather coarse, subcrystalline grains, cemented with a chalky paste. It generally occurs in thick massive beds, and is capable of withstanding the action of the weather to a greater extent than most of the members of the Cretaceous system. This formation is usually found capping the highest elevations, and its presence may be nearly always recognized, even at a distance, by the peculiar flat-topped and castellated appearance it imparts to the hills. According to Dr. Riddell, it is finely displayed along the bluffs of Brazos river in Bosque, McLennan, and Hill counties; also along the Leon and Bosque rivers. The summits of the remarkable elevation known as Comanche peak, in Johnson county, and that of Shovel mountain, in Burnet county, consist of this rock. The fossils are chiefly Caprina, Cytherea, and Ammonites of undetermined species. (Trans. St. Louis Acad. Science, vol. I, 1860, pp. 583-584.)

In a previous paper the writer has described the Caprina limestone substantially as follows:

The Caprina Limestone.—Without any serious stratigraphic break in the chalky limestones the abundant Comanche Peak fauna disappears and there continue 300 feet, more or less, of chalks and chalky limestones of varying degrees of consistency, from a pulverulent condition to firm limestones, which seem to be a secondary condition of the chalk produced by superficial hardening. These hard layers form the table rock of the buttes and mesas of the extensive Grand Prairie region and are exposed in the river bluffs between Austin and Mount Bonnell, on the Colorado, where the chalk has been more or less hardened into firm limestones by the local metamorphism accompanying faulting. The lime-kilns and quarries immediately west of Austin are all located on this subdivision.

Accompanying these chalks and chalky limestones are well defined layers of exquisite flint nodules, occupying apparently persistent horizons in localities. The flint nodules are oval and kidney-shaped, ranging in size from that of a walnut to about two feet in diameter. Exteriorly they are chalky white, resembling in general character the flint nodules of the English chalk cliffs. Interiorly they are of various shades of color, from light opalescent to black, sometimes showing a banded structure. These flint nodules are beautifully displayed *in situ* in the Deep Eddy canyon of the Colorado, above Austin, where they can be seen occupying three distinct belts in the white chalky limestones.

Where these chalky limestones form the basis of extensive plateaus, such as the remnants of the Grand Prairie west and southwest of Austin,

the flints are left in great quantities as a residuum of the softer chalks (which are more readily decomposed into soils and washed away), and they cover large areas of country. They have also been transported eastward in past geologic times by marine and river action, and are distributed over large areas along the margin of the Black Prairie region as a part of the Post-Cretaceous gravels of that region. In some of these flints remarkable decomposition is exhibited, the products being geode-like cavities lined with quartz-crystals and pulverulent substance.

These are the only flint horizons, so far, at least, as is known to the writer, in the whole of the immense Cretaceous deposits of the United States. They occur about the middle of the Lower Cretaceous series instead of at the top of the Upper series, as in England. It was from these flints that the ancient and modern Indians made their flint implements, and the ease of their lithologic identity will be of value to the anthropologist in tracing the extent of the intercourse and depredations of former Indian tribes inhabiting this region. Occasionally the flints, especially an opalescent variety in Comanche county, possess nuclei in the shape of fossils, usually *Requienia*.

The decomposition of these flints and of the adjacent limestones has produced some peculiar and unique effects in the rocks and landscape of the region, the silica replacing the calcium carbonate and leaving as a remnant a peculiar porous cavernous rock, usually of a deep-red color from the hydration of the iron pyrites into limonite, composed of the siliceous pseudomorphs of fossil *Rudistes* and other shells, the interstitial spaces glittering with minute quartz crystals which line them.

Immediately west of Austin, along the downthrow of the great Bonnell fault in the bluffs of the Colorado, another peculiar transformation takes place in the Caprina limestone. Occasional red decomposing spots occur in the massive white chalky limestones. Upon closer examination the apparently non-fossiliferous limestone is seen to be undergoing decomposition into a dry pulverulent inflorescence, and as a residuum there remains a dry red dust containing exquisitely preserved calcite pseudomorphs of many rare fossils, such as recently described by Roemer and White, the occurrence of which I have located in this horizon.

Traces of the following economic products have been discovered: Potash, salt, strontianite, anhydrite, epsom salts, gypsum, and gold, but in quantities as yet unknown.

At Austin a fault of about 750 feet downthrow has broken this limestone division into two different areas, and hitherto confused its measurement.

The limestones are more resistant to erosion than the over and under lying strata, and hence form the summit scarps and mesas of the peculiar buttes and divides in Hood, Comanche, Hamilton, Bosque, Coryell, Lampasas, and other counties of the Grand Prairie regions of Central Texas. It also occurs as the surface of extensive prairie regions in western Williamson county. It also caps the summit of the Jehosaphat plateau in

northwestern Travis county, and the Edwards plateau to the south, where its surface outcrops, owing to rain sculpture, is weathered into extensive fields of "Karrenfelder" or miniature mountains.

The limitations of this group of strata have not been finally determined, but it should include as its upper members the Austin marble (the Upper Caprotina limestone and the lithographic flags of my local Austin section). No abrupt break is evident between these and the underlying beds which contain the Comanche Peak fauna of Shumard (Die Kriedebildungen bei Fredericksburg of Roemer). The detail of these beds at Austin have been given by Mr. J. A. Taff (who made the section under my supervision) in the Third Annual Report of the Texas Geological Survey.

Stratigraphically the Caprina limestone represents the culmination of the subsidence that progressed during the Comanche epoch.

Paleontologically the Caprina limestone beds are of the greatest interest, for in them we have the development of the aberrant *Chamidæ* and *Rudistes* of this country. They contain all the species of these families known to occur in the Cretaceous of the United States, with the two exceptions of the Caprotina-like *Coralliochama* of California and the large *Radiolites austinensis*-like forms so common in the equivalents of the Colorado group of the Upper Cretaceous in the Alabama, Texas, and Colorado regions. As it is clearly and distinctly overlain by the whole of the Washita division which corresponds to the Gault of Europe, as will be later shown by the writer, and is above the well-defined beds of the Trinity and Lower Fredericksburg division, it affords an important landmark in tracing the progress of marine life on this side of the ocean.

II.—Characteristic Fossils.

The fauna of the Caprina limestone has been little understood, owing to the unfortunate fact that many of its fossils have been attributed to other horizons. Shumard* included the Lower Caprotina limestone of the Trinity division in Hood county with the Caprotina limestone of the Caprina beds, and throughout his valuable literature one fails to find any distinction between them. A few years since my friend, Mr. George Stolley,

* Loc. cit., p. 584.

discovered a fauna in what is now known to be the Caprina limestone in the bluffs of the Colorado, a few miles west of Austin. Not knowing the horizon of these beds, he sent them to Dr. C. A. White, of the United States Geological Survey, and Dr. Ferdinand Roemer, at Breslau. Dr. White described several of the forms of aberrant *Chamidæ*, but owing to the lack of stratigraphic particulars he refrained from publishing any age conclusions.* Dr. Roemer published † beautiful illustrations of these fossils and described them with his accustomed skill, but at that time, not knowing the comprehensive character of the beds in the immediate vicinity of Austin and probably deceived by the lithologic resemblance of the matrix, he erroneously concluded that they came from the Austin chalk (Niobrara) of the Upper Cretaceous. His conclusions that the Austin chalk from which he supposed these fossils to have come was of Turonien age was undoubtedly correct. The Austin chalk abounds in many other species which justify such a conclusion, but not one of these species later described warranted such a conclusion, nor did they come from that horizon. The writer regrets that he is unable here to republish Dr. Roemer's excellent figures and descriptions of this fauna.

The following is a list of the species which I have observed from the Rudistes horizon in the Caprina limestone beds at Austin, Texas:

Parasmilia austinensis Roemer.
Pleurocora texana Roemer.
Pleurocora coalescens Roemer.
Cladophyllia furcifera Roemer.
Coelosmilia americana Roemer.
Holectypus Roemer.
Patella or *Pileolus* (?).
Chrysostoma.
Helicocryptus or *Adcorbis.*
Ziziphinus (*Calliostoma*).
Nerinea austinensis Roemer.
Nerinea cultrispira Roemer.

* Bulletin 4, U. S. Geological Survey, on Mesozoic fossils, by C. A. White, Washington, 1884.

† Paleontologische Abhandlungen Herausgegeben von W. Dames und E. Kayser, Vierter Band. Heft 4. Ueber eine Durch die Haeufigkeit Hippuriten-Artiger Chamiden Ausgezeichnete Fauna der Oberturonen Kreide von Texas von Ferdinand Roemer. Mit 3 Tafeln. Berlin, 1888.

Nerinea subula Roemer.
Glauconia (?).
Cerithium obliterato-granosum Roemer.
Cerithium austinensis Roemer.
Trochus texanus Roemer.
Solarium planorbis Roemer.
Natica (*Amauropsis*) *avellana* Roemer.
Requienia patagiata Ch. A. White.
Monopleura marcida Ch. A. White.
Monopleura pinguiscula Ch. A. White.
Lucina acute-lineolata Roemer.
Requienia patagiata Ch. A. White.

The following forms have a more general occurrence:

Ostrea munsoni sp. nov.
Radiolites texana Roemer.
" *davidsoni* sp. nov.
Requienia texana Roemer.
Ichthyosarcolithes anguis Roemer.
Monopleura marcida Ch. A. White.
Ammonites (*Buchiceras*) *pedernalis* von Buch.
" (*Schloenbachia*) *acute-carniatas* von Buch.

In addition to the foregoing numerous species have been described under the generic name of *Caprina*, owing to the occurrence in immense quantities of a fossil supposed to have belonged to that genus. These fossils, however, are usually imperfectly preserved, but it can now be said with assurance that none of them belong to that genus, but are mostly *Ichthyosarcolithes* or *Radiolites*. All of the so-called Caprinas heretofore described from Texas come from this horizon.

Most of the Austin species occur in the bluffs of the south bank of the Colorado and Barton creek, just west of Austin, as beautifully preserved calcite pseudomorphs. Usually the limestone is very barren of all fossils except the *Rudistes* and *Chamidæ*.

Other aberrant *Chamidæ* and *Rudistes* from the Texas Cretaceous have long been known, but their exact stratigraphic range has not been clearly stated. With the exception of *Radiolites davidsoni* herein described, the stratigraphic occurrence of all the species was unknown to their authors when they described them. Many were described from imperfect specimens, and all the writers previous to Dr. White's valuable contribution expressed

serious doubts as to the true generic position of the forms. It can now be said that, with the single exception of *Radiolites austinensis*, all of these forms in Texas come from the Caprina limestone. The following is a list of the forms thus far described:

CHAMIDÆ.

Diceras (*?*) Roemer.

Requienia bicornis Meek, 1876. Fort Lancaster, Texas.

" *patagiata* White, 1884. Near Austin, Texas.

" *texana* Roem., 1852; White, 1884. Near Austin, Texas. Highlands between New Braunfels and Fredericksburg. Marcou, 1858, reports this form at "Comet creek, on left bank of the False Washita."

Monopleura marcida White, 1884. Near Austin, Texas.

" *subtriquetra* Roem., 1852. Valley of San Saba and upper arm of Pedernales river.

" *pingiuscula* White, 1884. Near Austin, Texas.

" *texana* Roem., 1852.

Ichthyosarcolithes anguis Roem., 1888, Barton creek, west of Austin.

" (*?*) (*Caprina*) *crassifibra* Roem., 1849, 1852.

" (*?*) (*Caprina*) *guadalupæ* Roem., 1849, 1852.

" (*?*) (*Caprina*) *planata* Con., 1855. Oak creek, near Pecos, Texas.

" (*?*) (*Caprina*) *occidentalis* Con., 1855, 1857. Pecos river near mouth. (A. Schott.)

" (?) (*Caprina*) *texana* Roem., 1849.

Plagioptychus (*?*) *cordatus* Roem., 1888.

RUDISTÆ.

Radiolites (*Hippurites*) *texanus* Roem., 1849, 1852.

" *davidsoni* sp. nov.

All of the above species occur in the Caprina limestone. *Radiolites austinensis* Roemer, is the only other form from the Texas Cretaceous. It occurs in the Austin chalk, and is so radically different in every aspect that it hardly belongs in the same group with the lower forms. With the exception of *Monopleura* and *Requienia*, which range downward into the Trinity Division, all the other genera occur only in the Caprina limestone, appearing suddenly upon the scene with these beds and completely vanishing thereafter.

Radiolites texanus Roemer, which comes from the Caprina

limestone, was referred to the genus Hippurites by Roemer,* although upon reading his description as originally published it will be seen that he distinctly stated that it was exceedingly doubtful whether this form belonged to *Radiolites* or *Hippurites*. The name *Hippurites*, however, has gone forth in literature, and, inasmuch as this genus is a characteristic form of the Upper Cretaceous of Europe, its supposed occurrence in the Lower Cretaceous of Texas has been the greatest obstacle to man in accepting the lower position of the Comanche Series. I am now prepared to state that there is not a single *Hippurites*† in either the Lower or Upper Cretaceous of Texas, and that this unfortunate impression should no longer prevail.

III.—Age of the Caprina Limestone.

The writer does not feel prepared to separate the Caprina limestone from the remainder of the Fredericksburg Division as a unit for the discussion of homotaxy, and in the following remarks it should be remembered that the beds are stratigraphically related.

Dr. Fred. Roemer, in his classical monograph of the Kreidebildungen von Texas, placed the beds which are now known to be the Caprina limestone at the very top of the Texas Cretaceous and referred them to the Senonien. Forty years later he unknowingly described more of the fauna from the same beds and placed them in the Turonien.‡ In earlier writings I § have shown the erroneous impression under which Dr. Roemer thus placed these beds, and that instead of occurring above his Turonien (Austin chalk beds) they are stratigraphically below them, and hence could not be Senonien.

Shumard, who first defined and applied the present name to the beds whose fossils had been described in part by Roemer, also failed to discover the true stratigraphic position, and likewise placed them at the top of the Texas Cretaceous.‖

---

* Kreide, von Texas, p. 76.

† In the Third Annual Report of the Texas Geological Survey a species is mentioned by name only as "*Hippurites flabellata* sp. nov." from the Caprina limestone. No description whatever has been given of this form. From the writer's familiarity with the specimens in the Texas collection he thinks it probable that it must be a Radiolites.

‡ Paleontologische abhandlungen.

§ Am. Journ. Sci., vol. xxxvii, 1889, pp. 318–319. Ibid, April, 1893.

‖ Loc. cit.

The writer has repeatedly shown that the stratigraphic position of the beds was in the middle of the Lower Cretaceous or Comanche series instead of at the top of the Upper, as believed by Roemer and Shumard, and hence, aside from the paleontologic evidence, he would assign these beds to a still lower horizon, probably the Uppermost Neocomian, or Transitional Neocomian-Gault, for the following reasons:

1. The fauna does not contain a single characteristic genus or species of beds of higher position.

2. The beds occur immediately beneath the Washita Division, which contain numerous species resembling those of the Gault of Europe.

3. The beds bear a remarkable paleontologic and stratigraphic resemblance to the Requienia Limestone beds of France and the Spanish Peninsula, where similar limestones, with *Radiolites* and *Requienia*, abound in the Upper Neocomian.

IV.—Description of Species.

Ostrea munsoni sp. nov.

Plate XII.

Compare *O. Joanæ* Choffat. Recueil de Monographies Stratigraphiques Sur le Système Crétacique du Portugal, par Paul Choffat. Lisbon, 1885, p. 34, plate 1, figs. 1–7.

Very thin and flat; elongately sub-triangulate and marked by many well defined radiating ribs; the pallial extremity rounded; beak more or less acuminate and slightly deflected, and evidently slightly attached; the inferior valve slightly concave, nearly flat, and showing near its beak an area of attachment. The larger valve flatly convexed and only slightly larger than the lower; the ornamentation of both valves is similar, and as remarked by Choffat in his description of *Ostrea Joanæ* a very similar form from Portugal, the two valves present an appearance as if they had been plicated together, the one upon the other. Each shell is very thin, and the living space small. When closed together the thickness of both valves is hardly one-twentieth the length of the shell.

The finely fluted ribs are slightly sinuous, continuous from beak to base or sometimes bifurcated, alternating with short ribs extending only half way from base. This is especially true upon the lower valve. This species is easily distinguishable from all the other North American oysters by its extreme flatness and thinness.

I have observed only a few specimens. These occur with great scarcity in the Caprina limestone, in association with *Radiolites davidsoni* at Belton and near Austin. The species is named in honor of Mr. T. V. Munson, of Denison, Texas.

This species resembles in general form the excellent figures of *O. Joanæ* Choffat, from the Cretaceous of Portugal.

Radiolites davidsoni sp. nov.

Plate XIII.

Description of Figured Specimen.—Very elongate, measuring over 40 centimeters; slightly flaring at larger end and gently tapering to small extremity; somewhat sinuous, pointed, and attached at lower end; exterior surface strongly marked by longitudinal ribs and grooves, as follows: Two especially broad and conspicuous grooves extending the entire length of the shell on opposite side to that shown in large figure, but seen in small segment and end view. These are accompanied by two large corresponding oblate ribs and a sharp, angular carina. These two grooves, ribs, and carina occupy one of the sides of the subtriangular circumference. The carina is very prominent and sharp, and extends from the smaller end to within about ten centimeters of the large extremity, where it becomes exfoliated and deflected like a mantle over and across the large ribs and grooves. This carina forms the upper margin of the large figure, and the angles seen in the cross-sections, and is opposite the smaller angle of the semi-lunate interior. It is bordered upon one side by one of the major grooves above described and upon the other by the somewhat flattened face shown in the figure of larger cross-section, on Plate XIII. The remaining two-thirds of the surface of the shell is marked by about fifteen small linear ribs, separated by wide, slightly concave depressions. Interior of shell a hollow cavity subpyriform or semilunate in cross-section, and marked by a few widely separated concave partitions occurring at intervals of three to five centimeters. Opposite the left hand major groove there is a slight projection extending the length of the interior which makes a narrow sinus in the casts when found. The interior is usually filled with calcite crystals.

Shell, irregularly thick, varying from three-quarters to one-half centimeter in different parts of the circumference. Outer surface is very smooth between the flutings and marked by fine

cross-striæ, which are the exterior terminals of the circumscribant septæ of the honeycombed structure. The shell is composed of two layers (see fig. 1). The outer one (*a*) is very thick and constitutes most of the substance and has a fine cellular honeycombed structure. Cells very minute and rectangular in cross-section and produced by the intersection of the concentric and vertical laminæ. The imbricate concentric laminæ are arranged in successive layers diverging upward from the interior layer of the shell. The interior shell (*b*) is thin and very poorly preserved, being largely replaced by calcite crystals.

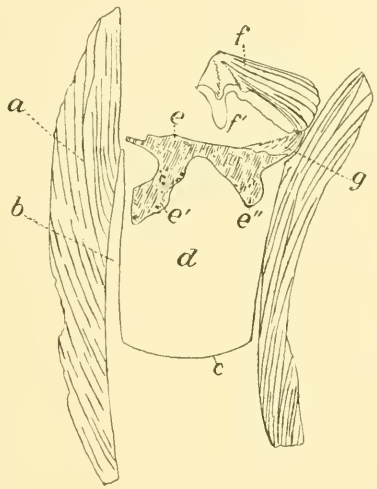


FIG. 1.—*Longitudinal section of larger extremity of specimen figured on plate xiii.*

a, outer shell of larger valve; *b*, space once occupied by inner shell of same; *c*, a cross-septum of interior cavity; *d*, last chamber of interior cavity; *e' e''*, calcified area, marking position of the muscular apophysis of upper valve; *f*, small fragment of upper valve; *f'*, section of outer edge of apophysis; *g*, undetermined fragment.

The opening of the shell is composed of the thin interior shell and a few layers of the exterior shell. Most of the concentric laminæ of the latter gradually disappear before reaching this termination. The dwelling chamber is about one and one-half centimeters deep, and the details of its structure somewhat concealed by the filled-in matrix. A longitudinal section of the large extremity (fig. 1) gives no detail of the anatomy of the living chamber, but gives some light on the upper valve.

Upper Valve.—No satisfactory specimen of the smaller valve has been found. In the specimen figured on plate XIII and in accompanying figure at *f* there is a fragment preserved, superficially resembling the shell of a Pecten, which, however, upon careful inspection appears to be a broken remnant of the smaller upper valve. It is composed of strongly radiating ribs alternating with finer lines, and in the longitudinal section shows a well-defined apophysis (*f*) corresponding to one of the casts preserved in the larger valve (*e″*). The section also shows distinctly the casts of the two muscular apophyses (*e′ e″*) of the small valve, as in Radiolites.

The generic position of this form has been perplexing, and possibly it deserves a distinct generic position. That it is nearer *Radiolites* than *Hippurites* is clearly shown by the absence of many of the characteristic features of the latter genus, such as the numerous partitions which cross the interior cavity; the different structure of the dwelling-chamber, and the presence of only two instead of three longitudinal sutures. Upon the other hand, it possesses many of the distinguishing characteristics of *Radiolites*, such as the prominence of the two well-defined longitudinal sutures and the structure of the interior cavity. It also differs from the genus *Sphærulites*, which is characterized by one longitudinal suture. The cells are mostly rectangular, while of the genus *Radiolites*, according to Zittel, there are five or more sided. This distinction has been used by some writers to make new genera, but the writer prefers to defer such action.

The form occurs in great abundance in the limestones near the water's edge of the Lampasas and Leon creeks, in the eastern suburbs of Belton, Texas, from whence the type specimens were collected by Professor Wilson T. Davidson, in whose honor it is named. It is also abundant near Round Rock and Austin. There is a possibility that this species may be the same as the form entitled "*Hippurites texanus*" of Roemer, figured and described in Die Kriedebildungen von Texas, of Roemer; but however strong the inclination may be to think they are the same, his descriptions and figures are so radically different that they cannot be said to be identical.

H. texanus, as figured, shows the cells to be polyginal instead of rhomboidal, as in *R. davidsoni*, and the surface grooving and cross-sections are entirely different in detail.

R. davidsoni shows great variation in length, some of the forms being very stunted and much thicker than the specimen figured.

Plate XII.

Ostrea munsoni sp. nov.

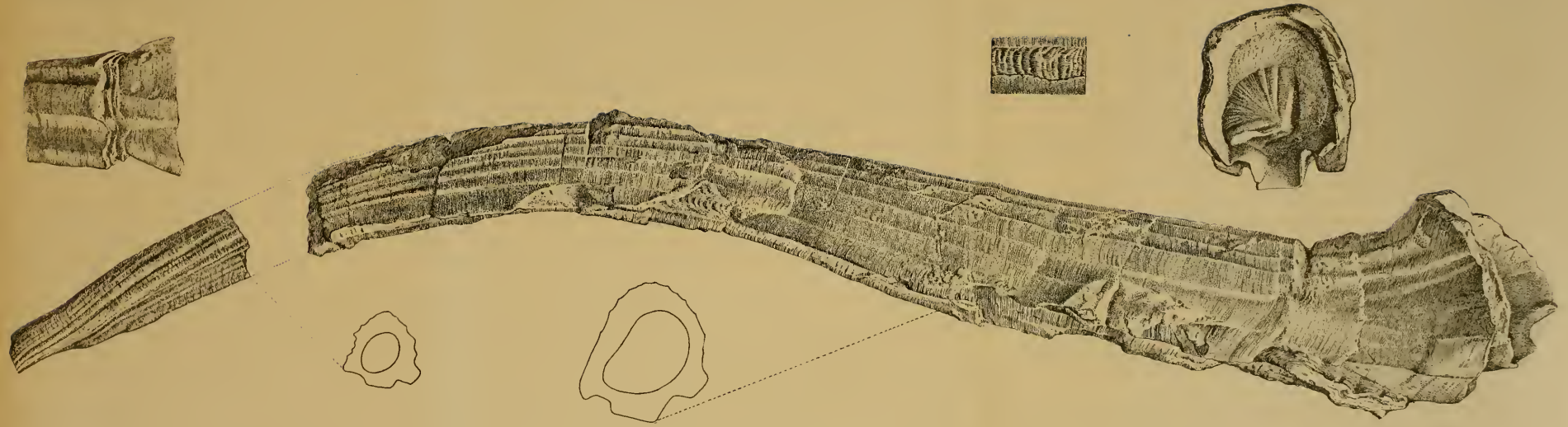
Three figures showing one view of an adult form and two views of medium-sized specimen. The older specimen shows larger valve on top exposing portion of lower valve at pallial margin. Both sides of the smaller specimen are shown, the smaller valve at the upper right-hand corner of the plate and the larger valve at the lower left-hand corner.

Ostrea munsoni sp. nov.

Plate XIII.

Radiolites davidsoni sp. nov.

The illustrations show an elongated specimen with details of its general structure. In the lower right-hand corner is a figure showing the two main sutures, which extend the entire length of the shell, but are not seen in the large illustration. In the lower left-hand corner is an end view of the specimen figured. The object in the upper right-hand portion of this figure is a fragment of the broken upper valve.



Radiolites davidsoni sp. nov.

Vol. VIII, pp. 109-112 July 31, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

TWO NEW WOOD RATS FROM THE PLATEAU REGION OF ARIZONA (*NEOTOMA PINETORUM* AND *N. ARIZONÆ*)

With Remarks on the Validity of the Genus Teonoma of Gray.

BY C. HART MERRIAM, M. D.

The two new mammals herein described are of unusual interest, not only because they are very distinct from any heretofore recognized, but also because they inhabit a region that has been pretty thoroughly explored during the past few years, and from which an unusually large number of mammals have been already described.*

One of the new species (*N. arizonæ*) presents a remarkable combination of the external characters of the bushy-tailed wood rats (genus *Teonoma* of Gray) with the cranial characters of the round-tailed species (*Neotoma* proper). The other (*N. pinetorum*), is a round-tailed species allied to the *N. fuscipes* group of California. Incidentally, the study of *N. arizonæ* led to the discovery of an important character that serves to distinguish *Teonoma* from *Neotoma*.

* No less than twenty new species and subspecies were discovered in my biological survey of the San Francisco Mountain region in Arizona in 1889 (see N. Am. Fauna, No. 3, Sept., 1890); and others have been described from the same general region by Dr. Edgar A. Mearns and Dr. J. A. Allen.

Neotoma arizonæ sp. nov.

Type from Keams Cañon, Apache county, Arizona. No. $\frac{42419}{49580}$ ♀ ad. Merriam collection. Collected by J. Sullivan May 21, 1888.

General Characters.—Tail bushy as in *Neotoma cinerea*, but narrower; animal similar to *N. cinerea* in general appearance, but smaller, and agreeing with the round-tailed species in important cranial characters. Ears large, measuring about 34 mm. from anterior base; whiskers long and coarse, reaching shoulders. Total length about 365 mm.; hind foot about 35 mm. (in an old male from the same locality the hind foot measures 39 mm.). Except for its superficial resemblance to *N. cinerea*, this animal needs no comparison with any known species.

Color.—Upper parts everywhere bright ochraceous-buff, moderately mixed with black-tipped hairs; under parts and feet pure white. Tail bicolor: grayish brown above, white below.

Cranial and Dental Characters.—Skull smaller and much shorter than that of *N. cinerea*, with shorter nasals and nasal branches of premaxillaries, and larger and much more inflated audital bullæ. The most important cranial character, however, contrasted with *N. cinerea*, is the presence of a broad slit-like opening on each side of the presphenoid and anterior third of the basisphenoid, as in the round-tailed species generally. In the bushy-tailed *N. cinerea* this slit is completely closed by the ascending wings of the palatine bones. The molar teeth are actually as large as and relatively larger than in *N. cinerea*. The enamel pattern of the last upper molar is a nearly perfect trefoil, though the posterior reëntrant angle on the outer side is shallower than the anterior.

Variation.—The males are considerably larger than the females, and the young are gray in color, as usual in the genus. The Keams Cañon specimens are very uniform in color. An immature male from Tres Piedras, Taos County, New Mexico, collected by J. Alden Loring July 4, 1892 (No. 53016, United States National Museum, Department of Agriculture collection), has the upper parts gray, tinged with buffy-ochraceous, and the white of the under parts clouded posteriorly from the plumbeous of the under fur. A specimen from Fort Wingate, New Mexico, collected by Dr. R.W. Shufeldt (No. 3358 ♂, Merriam collection) is a little older, but evidently not adult. It has the upper parts more strongly suffused with pale ochraceous and the belly white. Its tail is less bushy than any of the other specimens examined. A young-adult female, collected at Winslow, Arizona, by Clark

P. Streator (No. 53517, United States National Museum, Department of Agriculture collection) has the under parts stained a deep salmon pink from the soil. This color washes out, leaving the belly pure white as in the Keams Cañon specimens.

Geographic Distribution and Faunal Position.—*Neotoma arizonæ* inhabits the Tusayan or Moki district in eastern Arizona, and adjacent parts of the Painted Desert on the west, and New Mexico on the east. In all, eleven specimens have been examined: eight from the Moki country, one from Winslow in the Painted Desert, one from Tres Piedras in northern New Mexico, and one from Fort Wingate, near the western border of New Mexico. The species evidently belongs to the Upper Sonoran zone.

Neotoma pinetorum sp. nov.

Type from San Francisco Mountain, Arizona. No. $\frac{176932}{24628}$ ♀ ad. United States National Museum, Department of Agriculture collection. Collected by Vernon Bailey August 16, 1889 (original number, 366).

Measurements of Type Specimen (taken in flesh).—Total length, 355; tail vertebræ, 163; hind foot, 37; ear from anterior base, 25 (measured in dry skin). Average measurements of four adult specimens—total length, 362; tail vertebæ, 166; hind foot, 36.7.

General Characters.—Similar to *N. fuscipes* from southern California, but averaging slightly smaller; tail, ears, and hind feet shorter; tail more hairy; hind feet pure white [not clouded with dusky as in *N. fuscipes*]; back more strongly suffused with fulvous; whiskers long, reaching shoulders.

Color.—Upper parts fulvous, strongly mixed with black-tipped hairs; face from nose to above eyes gray, slightly grizzled, color of upper parts stopping at (or above) wrists and at ankles; under parts and feet white; tail sharply bicolor, above blackish, below white. Other specimens are less strongly fulvous, and the young are gray.

Cranial and Dental Characters.—Skull similar to that of the southern form of *N. fuscipes* but broader; brain case broader and shorter; palate and inter-pterygoid fossa longer; teeth larger (both molars and incisors).

General Remarks.—In my report on the mammals of San Francisco Mountain, Arizona, I referred the wood rat of the region to *Neotoma mexicana* of Baird.* At that time no typical specimens of *mexicana* were available for comparison. Since then, however, 14 specimens have been secured from the type locality, Chihuahua city, Mexico.

*North Am. Fauna, No. 3, Sept., 1890, p. 67, pl. x, figs. 5–8 (skull).

On reëxamining the specimens from San Francisco Mountain and comparing them with the duplicate types of *N. mexicana* they are found to be widely dissimilar, not only in external appearance, but also in cranial and dental characters. Singularly enough, the new species resembles *N. fuscipes* of California much more closely than *mexicana*. It is an inhabitant of the pine belt at the base of the mountain, and therefore belongs to the Transition zone. Its range probably meets that of *N. mexicana*, which inhabits the adjacent Painted Desert on the east and the Grand Cañon of the Colorado on the north. The avenue by which its ancestors originally reached the pine plateau region of Arizona becomes a geographic problem of no little interest. Its nearest ally, the southern form of *N. fuscipes*, is closely restricted to California, and no member of the *fuscipes* group has ever been reported from the Rocky Mountain region.

Remarks on the Validity of the Genus Teonoma of Gray.

In 1843 J. E. Gray separated the bushy-tailed wood rats generically from the round-tailed species under the name *Teonoma*.* In this arrangement he was followed by Fitzinger in 1867†, but not by other writers. The only character ever assigned the genus *Teonoma*, so far as I have been able to ascertain, is its bushy tail, in contradistinction to the short-haired terete tail of *Neotoma* proper. I take pleasure, therefore, in calling attention to an important cranial character which seems to have been overlooked. In the skulls of the round-tailed wood rats there is a long open slit on each side of the presphenoid and anterior third of the basisphenoid. These openings may be designated the *sphenopalatine vacuities*. In the bushy-tailed species (*Neotoma cinerea* and *N. cinerea occidentalis*) these vacuities are absent, being completely closed by the ascending wings of the palatine bones. Whether this character is of generic or subgeneric value may be left an open question for the present; that it is a character of considerable importance cannot be denied.

The most interesting feature connected with the new *Neotoma arizonæ* herein described is that while it agrees with *Teonoma* in the possession of a bushy tail, it has the spheno-palatine vacuities of *Neotoma* proper.

* List of Specimens of Mammalia in the British Museum, 1843, p. 117.

† Sitzungsberichte Math.-Nat., Cl. K. Akad. Wiss. Wien, vol. LVI. Abth. I, 1867, p. 77.

VOL. VIII, PP. 113-116 AUGUST 16, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

NOTES ON *THOMOMYS BULBIVORUS*.

BY GERRIT S. MILLER, JR.

Thomomys bulbivorus was accurately described by Richardson more than sixty years ago,* but has remained, save for this author's account, entirely unknown to naturalists almost to the present day. Richardson's description of *Diplostoma* (?) *bulbivorum* was based on a "Camas-rat" from the "banks of the Columbia," a region of which the mammalian fauna has until recently been very imperfectly known; hence it is no surprising circumstance that this gopher has been so long overlooked by collectors.

In the spring of 1890 Mr. A. W. Anthony took, at Beaverton, Washington county, Oregon, three specimens of *Thomomys* that soon after came into my hands and were immediately identified with the subject of Richardson's description. Lack of proper material to determine the questions of nomenclature raised by this discovery prevented any publication at the time, and the matter was allowed to rest. Recently, however, Dr. J. A. Allen, with an abundant supply of specimens at his command, reviewed a number of vexed questions concerning the synonomy of various species of *Thomomys*, and at his request the Anthony skins were placed at his disposal, the rediscovery of this long-lost animal being soon after announced,† while the

* Fauna Boreali-Americana, I, 1829, 206.

† Bull. Am. Mus. Nat. Hist., v, 56, author's edition, published April 28, 1893.

Thomomys bulbivorus of Baird and subsequent authors was referred to the *Oryctomys* (*Saccophorus*) *bottæ* of Eydoux and Gervais.

Although the rediscovery of this fine gopher has thus been made known, it still remains to redescribe the animal, which I propose to do as follows:

Thomomys bulbivorus (Richardson).

Diplostoma (?) *bulbivorum* Richardson. Fauna Bor.-Am., i, 1829, 206, pl. xviiib (lettered "douglasii" by mistake).

Thomomys bulbivorus Allen. Bull. Am. Mus. Nat. Hist., v, April 28, 1893, 56, pl. i, fig. 14 (skull).

Specific Characters. Largest known species of *Thomomys;* colors very dark; white markings about mouth extensive and in striking contrast; tail almost naked; skull exceedingly large and heavy.

Adult (♀ No. $\frac{3}{2}\frac{9}{2}\frac{7}{5}$, collection of Gerrit S. Miller, Jr., Beaverton, Washington county, Oregon, May 5, 1890; A.W. Anthony, collector); dorsal surface mixed clove-brown and yellowish chestnut, the hairs everywhere slaty plumbeous at base, the three colors indescribably blended, but the clove-brown predominating on the head and mid-dorsal region though without forming a distinct dorsal stripe, this giving way on the sides to the chestnut, which in turn is replaced on the belly by slaty plumbeous; narrow ring around ear, muzzle, lips, outer edge of cheek-pouches, and ill-defined area extending thence to front legs very dark brown, almost black; linings of cheek-pouches and broad space between white, in striking contrast with surrounding color; a small white anal spot; dorsum of manus brownish, of pes white; a white tuft at proximal base of large tubercle on palm; tail very sparsely clothed on basal third with brownish hairs, which are not sufficiently numerous to conceal the skin; this in the dried specimen yellowish white, dark brown for 10 mm. at tip.

The three specimens differ but little among themselves in color, the variation, such as it is, being due to the varying amount of clove-brown in the fur of the back. This is a trifle less in the two males than in the female. In one of the males (No. $\frac{3}{2}\frac{9}{2}\frac{9}{7}$) there is an indistinct wash of mars-brown on the belly. The dorsum of the right hind foot of No. $\frac{3}{2}\frac{9}{2}\frac{8}{6}$ is covered with brown hairs. This, however, must be purely accidental.

Unfortunately the specimens were not measured in the flesh, but as they have been prepared with much care the following measurements taken from the dry skins are not without value:

No.	*Sex.*	*Date.*	*Length.*	*Tail.*	*Hind foot.*
397/225	♀	May 5, 1890	260	74	37
398/226	♂	May 12, 1890	280	73	41
399/227	♂	May 12, 1890	255	67	38

The longest hind foot among thirteen specimens of *T. bottæ* from Nicasio, Marin county, California, is 32 mm.; shortest, 28 mm.; average, 29.7 mm.

Thomomys bulbivorus differs from *T. bottæ* so greatly in color, as well as in size, that a detailed comparison of the two animals is scarcely necessary. In *T. bottæ* the prevailing tint throughout is wood-brown, more or less mixed with russet dorsally and blackening about the mouth, muzzle, and cheek-pouches. The latter are here, as in *T. bulbivorus*, lined with white; the area between, however, is usually dusky, sometimes more or less marked with white, but never, or at least very exceptionally, wholly white.

The skull of *Thomomys bulbivorus*, in addition to its very much greater size, differs from that of *T. bottæ* in many details of structure. The occipital portion is broader and flatter (ratio of height from inferior lip of foramen magum to mastoid width 50 in *bulbivorus*, 54 in *bottæ*) and the fronto-palatal depth proportionally greater. The dorsal aspect shows no decided points of difference, though in *T. bulbivorus* all ridges and muscular attachments are more strongly accentuated. Ventrally, however, important differences at once present themselves. That surface of the exoccipital which appears on the ventral aspect of the skull immediately laterad of the condyle is in *T. bulbivorus* occupied by a deep groove running obliquely to the axis of the skull, while in *T. bottæ* the surface is almost flat. The basi-occipital is much broader in proportion to its length in *bulbivorus* than in *bottæ;* the audital bullæ of the former are much flatter and less inflated than in the latter. The form of the pterygoids differs markedly in the two species, those of *T. bulbivorus* being much the larger and strongly concave internally with hamulars converging at the tips, while in *T. bottæ* these bones are flat, with hamulars divergent posteriorly. Both foramen magnum and external nares are broader in proportion to their height in *T. bulbivorus* than in *T. bottæ*. Except in size, the mandibles and teeth of the two species show no distinctive characters.

The following table of cranial measurements and ratios of *Thomomys bulbivorus* and *T. bottæ* will serve to illustrate some of these differences in greater detail.

Cranial Measurements and Ratios of T. bulbivorus and T. bottæ.

	T. bulbivorus.			*T. bottæ.*			
Number	225	226	227	416	1183	1184	1187
Sex	♀	♂	♂	♂	♂	♂	♂
Basilar length	53	49	51	44	40.6	40	41.8
Basilar length of Hensel	50	46.2	48	41.6	38.2	37.8	39
Zygomatic breadth	39	.....	35.5	30.6	29	28.4	27
Mastoid breadth	32.4	29.8	30	24	21.4	22	22.2
Interorbital constriction	7.2	7.8	7.4	6.8	6	5.4	6
Greatest length of nasals	21	18.2	20	16.8	15.8	15	15
Incisor to molar (alveoli)	23	21	22.2	18	16.6	16	17
Incisor to post-palatal notch	35.4	33.2	35.4	29	27	26	27
Height of crown from inferior lip of foramen magnum	16	15	15.4	13	12.2	12	12.2
Fronto-palatal depth at middle of molar series	23.4	21.5	22.4	17	16.4	16.2	16.6
Height of foramen magnum	6	6.4	6.4	6	5.8	5.8	6.2
Width of foramen magnum	7.8	7.8	7.4	5.2	5.4	5.2	5.2
Greatest length of basi-occipital	11.6	11.6	11	10.4	9.8	9.6	9.8
Greatest width of basi-occipital	11	11.2	10.6	8.2	8	8.2	8.6
Length of maxillary molar series on crowns	10	8.6	9.8	8.4	8	8	7.4
Length of maxillary molar series on alveoli	11	10.4	11.4	9.2	9	9	8.4
Greatest length of mandible	37.2	42.4	40	33.6	30.2	31	31.4
Length of mandibular molar series on crowns	9	9.4	9.6	8.8	8	8.4	8.2
Length of mandibular molar series on alveoli	10.4	11	11	10.2	9	9.2	9
Ratios to basilar length of Hensel—							
Of zygomatic breadth	78.00	.....	73.95	73.55	75.91	75.13	69.23
Of mastoid breadth	64.80	62.55	62.50	57.69	56.02	58.20	56.92
Of fronto-palatal depth	46.80	46.53	46.60	40.86	42.93	42.59	42.56
Of occipital depth	32.00	32.46	34.41	31.25	31.91	31.74	31.28
Of nasal bones	42.00	39.39	41.60	37.98	41.36	39.41	38.46
Of maxillary molar series (crowns)	20.00	18.61	20.41	21.92	20.94	21.21	18.97
Foramen magnum: ratio of height to width	76.92	82.05	87.56	115.38	107.40	111.53	119.34
Basi-occipital: ratio of length to breadth	105.45	103.57	103.77	126.82	122.50	117.07	119.23

VOL. VIII, PP. 117-120 DECEMBER 21, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

MARINE BIOLOGICAL LABORATORY

DESCRIPTION OF A NEW SPECIES OF *LAGOMYS* FROM ALASKA.*

BY E. W. NELSON.

Lagomys collaris sp. nov.

THE COLLARED PIKA.

Lagomys princeps Nelson and True, Report upon Natural History Collections in Alaska, pp. 273, 274, 1887 (not Richardson).

Type collected about 200 miles south of Fort Yukon, Alaska, near the head of the Tanana river. No. $\frac{14388}{36297}$. U. S. National Museum. Collected by E. W. Nelson, 1880. (Original No., 164.)

Distribution.—Mountains south of Fort Yukon, about the head of the Tanana river, to the Chigmit mountains, near the head of Bristol bay, Alaska.

Among the mammals secured by me in Alaska were three specimens of *Lagomys* which appear to belong to an undescribed species. They were obtained, at my request, through the kindness of Mr. L. N. McQuesten, from the mountains south of Fort Yukon, by the Indians of that district.

Mr. McQuesten informed me that the Indians report these animals as common everywhere in the highest ranges south of Fort Yukon, where they are usually found above timber line. From native accounts their habits appear to be identical with those of the more southern species. I showed the skins to a fur-trader who had lived for many years at Kolmakovsky Redoubt,

* Presented at a meeting of the Biological Society of Washington, December 2, 1893.

on the Kuskoquim river; he recognized them at once, and told me that the species is common in all of the high mountains of the Alaskan range south of the Kuskoquim as far as the base of the peninsula of Alaska. In confirmation of this reported range are two skins, now in the United States National Museum, taken in the winter of 1882, in the Chigmit mountains near the head of Bristol bay, by Mr. McKay, which, though in shabby condition, appear to belong to the same species. The three skins secured by Mr. McQuesten were taken by the Indians during a summer hunt, and are presumably in summer pelage, although possibly taken in spring, before the molt.

The Chigmit Mountain specimens are in winter fur, and are much more ashy than those from the type locality.

The species thus has a known range from the high mountains south of Fort Yukon, in about latitude 65°, southwesterly to the vicinity of Bristol bay. Its northeast limit along this line coincides with the same limit of *Mazama montana*, and here occupies the southern part of the range of *Ovis dalli*. Its eastern extension remains a matter of uncertainty, but the type locality of Richardson's *L. princeps* makes it probable that *collaris* does not reach eastward to the mountains about the head-waters of the Mackenzie. That it does not range north of the Kuskoquim, along the course of that stream, was pretty definitely determined by my work in that region.

Description.—The dorsal surface, including top and sides of the head, is of a nearly uniform dark or grizzled-gray, with a dull yellowish wash on the crown and back. On the back and sides of the neck the yellowish wash is nearly or quite lacking, leaving a broad collar of dull iron-gray separating the yellowish-shaded areas of the head and back. This yellowish wash is much more apparent on the crown and middle of back and fades out at the sides, so that next the border of the white lower surface the color becomes ashy-gray. Just behind each ear is a small area of dull, light ashy. Below, a triangular white area occupies the entire chin and throat, with its apex in front. At each of the two posterior angles of this area is a yellowish spot forming a slight backward continuation of the light area of the throat at these points. These spots lie on the sides of the throat below and a little behind the ears. The white-throat area is well defined, and is succeeded by a distinct band of dull gray, which forms the lower part of the cervical collar. The remainder of

the lower parts are pure white, including the feet and legs, except only the smoky-brown fur on the soles of the hind feet. The fore feet and legs to well above their insertion are included within the pure-white area of the lower surface. The exposed portion of the interior of the ear-conch is covered with a strong growth of coarse hairs. These hairs are pale gray at base, shading into yellowish toward the distal third, and the remainder of tip shiny black. The distribution of the hairs is such that the colors form a distinct yellowish band across the middle of the ear, succeeded by a very distinct black bar that extends along the edge and, at first glance, appears to form a black band bordering the ear. A close examination, however, shows that behind this black bar the actual margin of the ear is very narrowly edged with pale grayish-white. The black bar is about 3 mm. in width, and is distinct in all the specimens examined. The under fur of the dorsal surface is slaty-black. Above this slaty-black area the longer hairs have a narrow band of pale gray shading into a broader zone of dull yellowish, followed by a distinct black tip.

The two winter specimens from the Chigmit mountains are without any of the yellowish wash of the skins from the type locality, and the long hairs are mainly pale ashy with faint blackish tips, so that the color is a pale ash-gray. The still paler collar separating the uniform color of head and back is present, as is the dull-gray band across the neck below; otherwise they are colored similarly to the type specimen. All of the specimens have very long pelage as compared with the southern species, and this is especially noticeable in the three specimens from south of Fort Yukon, on which the long dorsal hairs reach an average length of over 22 mm.

Measurements.—The following average measurements in millimeters of five dried skins are given merely to serve as an approximation to the true dimensions: Total length, 182; hind foot, 28.3; ear, 19.1 (measured from anterior base).

Compared with *L. princeps* from Idaho and *L. schisticeps* from the Sierra Nevada of California, the following are the most striking external differences: The hairy, strongly marked ears of the Alaskan animal are conspicuously different from the two southern species, both of which latter have the ears thinly covered in front with very short hairs and a much more conspicuous whitish border. On both *schisticeps* and *princeps* the yellowish or fulvous

wash of the upper surface becomes most distinct along the sides bordering the white lower surface, while in *collaris* it is absent in this region and is most conspicuous on the upper surface of head and back. There also appears to be a higher upward extension of the lower white area along the sides of the latter species. The plain gray of the collar below on the Alaskan animal is replaced on the other species by a band of fulvous or yellowish, which is inclined to spread over the adjoining parts and commonly shades nearly or quite all of the lower surface. There is no sign of this in any of the five specimens of *collaris* examined by me. The uniform coloration of the upper surface of the head and back, separated by a differently colored collar, is another marked characteristic of *collaris*.

Contrasted with *L. princeps* and *L. schisticeps*, the most conspicuous cranial character of *collaris* is the much larger size of its audital bullæ. They appear to be larger in every dimension than in the other two species.

The post-palatal notch is broad, as in *schisticeps*, but the palatine bridge is broad and heavy and slightly concave on both borders. The interorbital width is greater than in *schisticeps*. The infra-condylar notch of the mandible is more deeply excavated than in either of the other species. In addition, the angular process is much more strongly upturned and ends in a sharp point rising vertically behind the concavity of the notch. The horizontal ramus of the mandible is slenderer than in *schisticeps* and much as in *princeps* from Idaho.

To the kindness of Mr. F. W. True, Curator of Mammals in the United States National Museum, I am indebted for the opportunity to examine the material on which the present paper is based.

Skull measurements of three specimens of Lagomys collaris from the type locality, two hundred miles south of Fort Yukon.

U. S. National Museum number	36297	36298	36296
Basilar length of Hensel	?	35.5	?
Greatest zygomatic breadth	21.5	21.5	?
Interorbital constriction	5.25	5.5	5.5

VOL. VIII, PP. 121-128 DECEMBER 21, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

JUNCUS MARGINATUS AND ITS VARIETIES.*

BY FREDERICK VERNON COVILLE.

Juncus marginatus has long been known as a species well distinguished from all others, but widely variable within its own limits. Writers on American botany in the early part of the present century gave different names to various forms of the plant, and not until 1866, when Dr. Engelmann published the first part of his Revision of the North American species of the genus Juncus, were they comprehensively treated as forms of *Juncus marginatus*.

The examination of the literature of *Juncus marginatus*, together with a large series of specimens, has brought the writer to separate the species into three forms, namely, *Juncus marginatus* (type form), *Juncus marginatus aristulatus*, and *Juncus marginatus setosus*, which may be presented as follows:

Juncus marginatus Rostk.

Juncus marginatus Rostk. Monog. Junc. 38, t. 2, f. 3 (1801). Type specimen from Pennsylvania.

Juncus cylindricus Curtis, Amer. Journ. Sci. xliv. 83 (1843). Type specimen from Lincolnton, North Carolina.

Juncus marginatus vulgaris Engelm. Trans. St. Louis Acad. ii. 455 (1866). Type locality not given.

* Presented at a meeting of the Biological Society of Washington, December 2, 1893.

Juncus marginatus paucicapitatus Engelm. Trans. St. Louis Acad. ii. 455 (1866). Type specimen from Long Branch, New Jersey.

Stems in close tufts, seldom exceeding 50 cm. in height; leaf blades 1 to 2.5 mm. broad; inflorescence commonly bearing 5 to 15 heads; heads usually 5- to 10-flowered; inner perianth parts broadly obtuse; seed narrowly oblong, 0.4 to 0.5 mm. in length, short-stalked at the base, attenuate-apiculate at the apex, marked with 12 to 16 conspicuous longitudinal costæ, the intercostal spaces minutely and closely translineolate, usually with an occasional transverse line similar to the costæ.

Specimens examined:

Ontario: Near Sandwich, J. M. Bigelow, September 2, 1866.

Maine: York, M. L. Fernald, July 16, 1891; Cumberland, J. Blake.

New Hampshire: East Jaffrey, Walter Deane, July 17, 1889.

Massachusetts: Ipswich, William Oakes; South Framingham, E. L. Sturtevant, 1890; Cambridge, M. L. Fernald, September 11, 1891; Chelsea Beach Island, William Boott, September 10, 1853.

Connecticut: Plainville, J. N. Bishop, 1888.

Rhode Island: Providence, George Thurber, June, 1845.

New York: Mariners Harbor, Staten Island, Arthur Hollick, September 5, 1886; Pine Plains, Lyman Hoysradt.

New Jersey: Long Branch, C. W. Short, 1856.

Pennsylvania: Lancaster county, T. C. Porter, July 31, 1886; Germantown, Thomas Meehan, 1867; Grays Ferry, Philadelphia, C. E. Smith; Wysox, John Carey, 1841; Westmoreland county, P. E. Pierron, August 11, 1866; Chester county, W. M. Canby, July, 1866; Tinicum, Bucks county, T. C. Palmer, August, 1892.

Delaware: W. M. Canby; Newcastle, Alexander Commons, 1866.

Illinois: Athens, Elihu Hall, 1864; Beardstown, C. E. Geyer.

Kentucky: Lexington, C. W. Short, 1835.

Missouri: Carter county, B. F. Bush, July 21, 1891.

District of Columbia: Near Washington, L. F. Ward, July 9, 1876, June 23, 1878, July 21, 1878, and June 14, 1879; Washington, M. S. Bebb, 1864.

Virginia: Between Princess Anne and Berkeley, A. A. Heller, No. 1074, July 13, 1893; along New River, Carroll county, altitude, 2,200 feet, J. K. Small, July 12, 1892; Colonial Beach, F. V. Coville, July 6, 1890; Ocean View, Norfolk county, F. V. Coville, June 21, 1890,

North Carolina: Lincolnton, Lincoln county, M. A. Curtis; near Salisbury, Rowan county, A. A. Heller, June 21, 1890; Carolina Beach, New Hanover county, F. V. Coville, June 27, 1890.

Florida: A. W. Chapman; Duval county, A. H. Curtiss, No. 2975 in part.

Juncus marginatus aristulatus (Mx.).

Juncus aristulatus Mx. Fl. i. 192 (1803). Type specimen from either the Carolinas or Georgia.

Juncus aristatus Pers. Syn. Pl. i. 385 (1805). Type specimen the same as that of *Juncus aristulatus*.

Juncus biflorus Ell. Bot. i. 407 (1817). Type locality, ten miles from Savannah, on the road to Augusta, Georgia.

Juncus marginatus odoratus Torr. Fl. Nor. U. S. i. 362 (1824). Type specimen from "Bloomingdale, near New York."

Juncus heteranthos Nutt. Trans. Amer. Phil. Soc. new ser. v. 153 (1832–37). Type specimen collected along the Arkansas River.

Juncus canaliculatus Liebm. Mex. Junc. 43 (1850). Type specimen collected near San Antonio Huatusco, in the state of Vera Cruz, Mexico, at the altitude of 1,370 meters.

Juncus odoratus Steud. Syn. Pl. Glum. ii. 304 (1855). Type locality the same as that of *Juncus marginatus odoratus*.

Juncus marginatus biflorus Engelm. Trans. St. Louis Acad. ii. 455 (1866). Type locality the same as that of *Juncus biflorus*.

Stems single or in loose tufts, usually exceeding 50 cm. in length; leaf blades 1 to 5 mm. broad; inflorescence usually bearing 20 to 100 heads, in depauperate plants sometimes fewer; heads usually 2- to 5-flowered, becoming occasionally 10-flowered; inner perianth parts broadly obtuse; seed as in the type form, but 0.5 to 0.6 mm. long.

Specimens examined:

New York: New York, at Bloomingdale, John Torrey.

New Jersey: Near Atsion, C. F. Parker, July 31, 1866; near Princeton, John Torrey, July, 1830; Burlington county, C. F. Parker, August 19, 1867; Dennisville, Cape May county, C. F. Parker, July 15, 1866.

Pennsylvania: West Chester, William Darlington, 1827.

Delaware: Ellendale, W. M. Canby, September 16, 1891; near Wilmington, Alexander Commons, July 7 and 24, 1866.

Maryland: Garrett county, J. D. Smith, July, 1879; Salisbury, Alexander Commons, July 27, 1865; Salisbury, W. M. Canby, June, 1864.

Virginia: Virginia Beach, Princess Anne county, Arthur Hollick and N. L. Britton, September 26 and 27, 1890; near Virginia Beach, A. A. Heller, No. 1053, July 12, 1893; Colonial Beach, F. V. Coville, July 6, 1890; Ocean View, Norfolk county, F. V. Coville, June 21, 1890.

District of Columbia: Near Washington, Lester F. Ward, July 21, 1878.

North Carolina: Wilmington, M. A. Curtis; near Wilmington, F. V. Coville, June 26, 1890.

South Carolina: Aiken, H. W. Ravenel, June 12 and 25, 1866, and August, 1869.

Florida: Duval county, A. H. Curtiss, No. 2975, in part; Fort Meade, Polk county, J. D. Smith, March, 1880; Gadden county, A. W. Chapman.

Alabama: Alexander Winchell, No. 162; Montgomery, Gerald McCarthy, 1888; Fly Creek, Baldwin county, Charles Mohr, June 13, 1890.

Mississippi: Starkville, S. M. Tracy, Nos. 1420, 1421, June 20, 1890; Ocean Springs, S. M. Tracy, No. 1648, July 10, 1891.

Louisiana: Josiah Hale.

Texas: Hardin county, G. C. Nealley, 1888; Houston, F. Lindheimer, 1842.

Michigan: Near Fort Wayne, J. M. Bigelow, July 28 to September 9, 1866.

Kentucky: Lexington, C. W. Short, 1835.

Kansas: Cherokee county, W. S. Newlon, 1893.

Missouri: St. Louis, C. A. Geyer, May, 1842.

Arkansas: F. L. Harvey, 1882 to 1884; Little Rock, H. E. Hasse, May 25, 1886.

Indian Territory: Choctaw agency, J. M. Bigelow.

Guatemala: Coban, Alta Vera Paz, altitude, 4,300 to 4,400 feet, H. von Turckheim, No. 431, April, 1886, and April, 1879.

Brazil: "Brasilia meridionali," Sellow.

Juncus marginatus setosus var. nov.

Stems apparently in loose tufts, 30 to 75 cm. high; leaf blades 1 to 5 mm. broad; inflorescence and heads as described in *Juncus marginatus aristulatus;* inner perianth parts narrowly ovate to lanceolate, 0.3 to 0.4 mm. in length, reticulated in 12 to 16 longitudinal rows, the areolæ nearly isodiametrical, transversely pluri-lineolate.

Type specimen in the United States National Herbarium, collected June 4, 1882, in the Santa Catalina mountains, Arizona, by C. G. Pringle.

Specimens examined:

Kansas: Stafford and Kingman counties, M. A. Carlton, 1891.

Nebraska: Minden, Kearney county, June, 1891, intergrading with the type form.

Arizona: Santa Catalina mountains, C. G. Pringle, June 4, 1882, and April 14 and May 16, 1881; Lowell, W. F. Parish, May 24, 1884; Apache Pass, J. G. Lemmon, No. 313, 1881.

New Mexico: Charles Wright, No. 1923 in part, 1851.

Indian Territory: Colbert, C. S. Sheldon, No. 37, June 19, 1891; Russell Creek, W. S. Newlon, 1893.

Texas: Drummond, F. Lindheimer, No. 193, 1843; Corpus Christi, H. W. Ravenel, April 30, 1869; Houston, Elihu Hall, Pl. Tex. No. 657, April 20, 1872.
Arkansas: Little Rock, F. L. Harvey, June, 1880.
Louisiana: Port Eads, on ballast ground, A. B. Langlois, May 6, 1885.
Mexico: Near Morales, San Luis Potosi, J. G. Schaffner, No. 500, 1876; Rio Blanco, Jalisco, Edward Palmer, No. 13, June 8, 1886.

The considerations which have led to the disposition of the species formulated above may be given in sufficient detail to aid the future student who goes over the same ground.

The type specimen of *Juncus marginatus*, which is probably at Berlin, it has not been possible to consult, but Rostkovius's excellent figure, as well as his description of the plant, "*culmus erectus pedalis vel sesquipedalis*," "*corymbus terminalis simplex*," and "*capitula octo- vel decemflora*," besides the type locality, Pennsylvania, leave no doubt as to the identity of the type form. The type specimen of *Juncus cylindricus*, a fragment of which I have been able to examine in the Engelmann herbarium, bears heads with abnormally elongated axes and many flowers. It belongs clearly to some form of *Juncus marginatus*, probably to the type form. Dr. Engelmann, following a practice in common European use, gave to what he considered the type form a varietal name, *vulgaris*, which, by reference to No. 33 of his Herbarium Normale, is seen clearly to be identical with Rostkovius's plant. An examination of the type specimen of *Juncus marginatus paucicapitatus* in the Engelmann herbarium shows that it belongs to the type form of *Juncus marginatus*, and indeed closely resembles Rostkovius's original figure of the species.

The plant for which the name *Juncus marginatus aristulatus* is here adopted has been known currently as *Juncus marginatus biflorus*. Michaux's *Juncus aristulatus* has been referred by various authors to *Juncus marginatus* without particular comparison with any of its forms, but an examination of his description leaves no doubt regarding the plant he was describing, for in the expression "*glomerulis trifloris*" he names the most conspicuous external feature of this variety. Persoon's specific name *aristatus* is an error for *aristulatus*, for Persoon cited Michaux as the author of the name, with reference to the page of publication, and quoted his description with but slight changes. Regarding *Juncus biflorus*, it should be said that Elliott included in his book descriptions of two plants of the *marginatus* group,

one, which he referred to *Juncus aristulatus* Mx. (citing it by error, apparently from Pursh, *Juncus aristatus*, and modifying Michaux's description to some extent), and another, which he described as a new species, *Juncus biflorus*, with the diagnosis "*Juncus culmo tripedali, tereti; foliis linearibus, planis; paniculu decomposita, elongata; glomerulis bifloris.*" There can be no doubt that this plant is referable to true *Juncus aristulatus*, and that Elliott incorrectly transferred Michaux's name to some other form, perhaps the type form, of *Juncus marginatus*. Torrey's *Juncus marginatus odoratus*, the original specimen of which I have examined in the Columbia College herbarium, is *Juncus marginatus aristulatus*, with 3- to 5-flowered heads, and has now lost the pleasant odor, probably accidental, attributed to it by Dr. Torrey. Nuttall's *Juncus heteranthos* can be nothing else than *Juncus marginatus biflorus*, for although his type specimen appears to have been lost he states explicitly in his description that the flowers are mostly in threes, and that the inner perianth parts are obtuse. In describing the plant, therefore, he appears to have been distinguishing it from the common typical eastern form of *Juncus marginatus* and not to have had in mind Elliott's *Juncus biflorus*. The form ascribed to the inner perianth parts precludes its reference to *Juncus marginatus setosus*. The type specimen of Liebmann's *Juncus canaliculatus* has been examined by Dr. Franz Buchenau, who refers it unhesitatingly to *Juncus marginatus*.* Since he does not say that its inner perianth parts are acute, I judge that it is not *Juncus marginatus setosus*, which, indeed, is very unlikely to occur in the humid climate of Vera Cruz. Neither is Liebmann's plant referable to the type form of *Juncus marginatus*, for that plant does not range so far south. The *Juncus odoratus* of Steudel is based on *Juncus marginatus odoratus* Torr., to which reference has already been made, and Engelmann's *Juncus marginatus biflorus* is based upon *Juncus biflorus* Ell.

The variety described above as new could not, from its range, have been referable to any of the plants whose names have been cited above as synonyms of *Juncus marginatus* or its variety, with the exception of *Juncus heteranthos* and *Juncus canaliculatus*, and the reasons for the reference of these two plants to *Juncus marginatus aristulatus* have been given in the last paragraph.

The localities of specimens examined in the preparation of

*Abh. Naturw. Ver. Bremen, iii. 343–344 (1873).

this paper have been taken from the labels in the herbaria of Harvard University, Columbia College, the Missouri Botanical Garden, and the Academy of Natural Sciences of Philadelphia, the private herbaria of Mr. William M. Canby and Captain John Donnell Smith, and the National Herbarium.

The disposition which is here made of the type form and varieties of *Juncus marginatus* may serve as a general illustration of a method of dealing with species and varieties which is in accord with our present knowledge of the evolution of species and of the geographic relationship of these plants with each other. The writer, having first secured a considerable amount of material, separated the specimens into the three groups which their examination naturally suggested. Next the names which have been published for any one of these forms were taken up and the original descriptions and the type specimens examined. In some cases the types were not accessible, and under those circumstances it was necessary to identify the plant either by description alone or by the aid of collateral evidence. In this manner it is believed that the earliest name applied to each of these forms has been ascertained, one of them, as it proved, having never before received a distinctive name. The next step was to bring together a still larger number of specimens, identifying each one according to the facts already known, ascertaining the locality in which it was collected, and marking its position upon a map. It was found that the type form of *Juncus marginatus* merges by a full series of intergrades into *Juncus marginatus aristulatus*, and that in the states of Nebraska and Kansas it seems to intergrade also with *Juncus marginatus setosus*. The latter shows a close relationship with the variety *aristulatus*, but, so far as indicated by the specimens examined, does not fully intergrade with it. The differences between these two, however, are so slight that there is reason to expect the occurrence of intergrades. The type form of *Juncus marginatus* ranges from Maine southward through the Atlantic States to Florida, and occurs again at a point in the province of Ontario opposite Detroit. The variety *aristulatus* ranges from New York city southward along the coastal plains to Florida, westward through all the States bordering the Gulf of Mexico, and northward, in the Mississippi valley, in apparently isolated localities, to southern Michigan. South of the United States it follows the eastern coast at least as far as Coban, Guatemala, and one specimen is reported to have

been found in southern Brazil. The variety *setosus* occurs in the southern Great Plains region, ranging over western Kansas, Indian Territory, interior Texas, Arizona, and New Mexico, and southward in Mexico to the states of San Luis Potosi and Jalisco. An isolated locality is also known on ballast ground in Louisiana and another in Arkansas. The ranges of the type form and the variety *aristulatus* appear to overlap in the Atlantic States over a considerable area, but in reality they are pretty well distinguished, for the latter characteristically inhabits sandy plains, particularly those along the coast, while the type form grows more abundantly in upland moist areas.

The most widely diffused and probably the mother form of *Juncus marginatus* is its variety *aristulatus*, which is characteristic of the coastal plains from New York to Texas, and extends far up the Mississippi valley, occurring among the coast mountains of Mexico southward to Guatemala. *Juncus marginatus* proper is an outlying and probably derivative form, extending farther north and farther inland, and presents a variation in the direction of smaller size, more reduced inflorescence, and larger heads. *Juncus marginatus setosus* is a second derivative, with acute, more papery perianth parts, and smaller seeds, characteristic of moist places in the subarid regions westward from the range of the mother form.

This test by geographic range has checked and emphasized the results obtained by a merely morphological examination of specimens, and brings our knowledge of these plants into a form more clearly expressive of their developmental relations. The same method may without doubt be applied to any group of plants with highly important results.

VOL. VIII, PP. 129-138 DECEMBER 28, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

MARINE BIOLOGICAL LABORATORY WOODS HOLE MASS.

DESCRIPTIONS OF EIGHT NEW GROUND SQUIRRELS OF THE GENERA *SPERMOPHILUS* AND *TAMIAS* FROM CALIFORNIA, TEXAS, AND MEXICO.

BY C. HART MERRIAM, M. D.

Among the undescribed rodents now in the collection of the Division of Ornithology and Mammalogy of the U. S. Department of Agriculture are eight new ground squirrels of the genera *Spermophilus* and *Tamias*. Five of these are specifically distinct from any heretofore described; the remaining three are well-marked subspecies. They are here described in advance of the more formal publications in which their relations and distribution will be discussed at length.

Spermophilus nelsoni sp. nov.

NELSON'S SPERMOPHILE.

Type from TIPTON, SAN JOAQUIN VALLEY, CALIFORNIA. No. 54651 ♂ ad. United States National Museum, Department of Agriculture collection. Collected June 24, 1893, by C. P. Streator (original number, 2968).

Measurements (taken in flesh).—Type specimen, ♂: total length, 228; tail vertebræ, 71; hind foot, 41. Mean of 29 specimens from type locality: total length, 228.6; tail vertebræ, 68.4; hind foot, 40.4.

General Characters.—Belongs to the subgenus *Ammospermophilus;* similar to *S. leucurus* in form and pattern of markings, but somewhat larger and widely different in color, the upper parts being yellowish-brown.

Color.—Upper parts dull yellowish-brown or buffy clay-color, which color covers the outer surfaces of the legs and the proximal third of the upper side of the tail; a white stripe on each side reaching from behind shoulder to rump; under parts, feet, and eyelids soiled whitish, the feet more or less strongly suffused with buffy. Tail above: proximal third buffy clay-color like back; distal two-thirds mixed black and whitish with a whitish border; tail below: soiled or buffy whitish, bordered on distal two-thirds with a broad subterminal black band, and edged with whitish. There is also a very narrow black zone at the base of the tail hairs. The upper parts are rather coarsely lined with black hairs which are absent from the legs, giving the latter a slightly different tint, and in some specimens the ground color of the legs and sides just above the forelegs is different, being suffused with dull buffy ochraceous. The fall and winter pelage is darker and softer than the summer pelage.

Cranial Characters.—Skull similar to that of *S. leucurus*, but larger and broader; audital bullæ conspicuously larger, more inflated and distinctly corrugated. The corrugations are due to the presence of two transverse constrictions, marking the position of vascular canals; they are faint or absent in *leucurus*, *harrisi*, and the other previously described forms. The rostrum and nasal bones are somewhat longer, and the upper incisors and first upper premolar are larger than in *leucurus*.

Specimens Examined (all from San Joaquin Valley, California).—Total number, 52, from the following localities: Tipton (type locality), 32; Huron, 7; Adobe Station, 1; Alila, 2; Lerdo, 2; Poso, 3; Temploa Mountains, 2; Lake Buena Vista, 3.

General Remarks.—The difference between *Ammospermophilus nelsoni* and the previously known members of the group is much more decided than between any of the others. The animal is larger, paler, and very different in color, the upper parts being everywhere from nose to tail a uniform dull yellowish or buffy clay-color, rather coarsely lined with black hairs. The cranial peculiarities have been already described. The fall molt evidently takes place early and progresses from behind forward, as shown by the 13 specimens collected by Mr. Nelson in October. All of these have completed or nearly completed the change, the only old hairs remaining being on the head and belly. In some of the specimens from Poso the pale, buffy clay-color of the head, still in worn summer pelage, is in striking contrast

with the much darker tints of the neck and back which are completely covered with the new coat. The two are separated by a sharp line of demarkation that crosses the occiput between the ears.

Heretofore no species of the *Ammospermophilus* group has been recorded from the San Joaquin Valley, or in fact from any point west of the great divide. It is remarkable that a diurnal mammal as conspicuous as the present species, and one inhabiting a region traversed by a railroad over which numerous mammal collectors have passed again and again, should have remained undescribed to the present day.

Spermophilus perotensis sp. nov.

PEROTE SPERMOPHILE.

Type from Perote, Vera Cruz, Mexico. No. 54274 ♀ ad. United States National Museum (Department of Agriculture collection). Collected by E. W. Nelson June 8, 1893 (original number, 4976).

Measurements (taken in flesh).—*Type specimen*: Total length, 253; tail vertebræ, 68; hind foot, 39. Average of 14 specimens from type locality: total length, 249; tail vertebræ, 69; hind foot, 38.5.

General Characters.—This spermophile does not require comparison with any known species. In size and external appearance it resembles *S. elegans* of Wyoming, but its cranial characters show it to belong to another subgenus (*Xerospermophilus*). Ears a mere rim; tail rather short.

Color.—Upper parts grizzled yellowish brown, vermiculated posteriorly by irregularly interrupted lines of black (which in immature specimens, and probably also in new pelage in adults, form the posterior borders of indistinct buffy spots); eyelids white; under parts and feet buffy. Tail above, grizzled yellowish brown and black, the black predominating on the distal half; below, ochraceous buff, with a distinct subapical band of black encircling the distal half or two-thirds.

Cranial Characters.—In cranial characters *Spermophilus perotensis* clearly belongs to the subgenus *Xerospermophilus*, and to that part of the subgenus from which the ancestors of *S. mexicanus* branched off. The adult skull is larger and heavier than that of any other known member of the *spilosoma* group, and resembles *S. spilosoma major* more closely than any other species. The parietals are much more highly arched above the supraoccipital, the highest point being between the postorbital pro-

cesses, behind which they are even more abruptly decurved than in *S. mexicana;* the supraorbital foramina are completely inclosed in the superciliary shelf. Molars heavy, their crowns very broad antero-posteriorly; first upper premolar relatively large. In many respects the skull of *S. perotensis* resembles that of *S. mexicanus.*

Geographic Distribution and Faunal Position.—The range of this species, according to Mr. Nelson, is "the extreme eastern border of the Mexican table-land at Perote, Vera Cruz, at an altitude of 7,800 or 7,900 feet." Its faunal position is along the upper border of the Upper Sonoran zone.

General Remarks.—Sixteen specimens of this new Spermophile are before me, all collected at Perote by Mr. Nelson. They vary but little, except in the degree of visibility of the obsolescent spots and the tint of the upper parts—differences resulting from the wearing off of the tips of the hairs.

Spermophilus spilosoma annectens sp. nov.

PADRE ISLAND SPERMOPHILE.

Type from Padre Island, Texas. No. $\frac{30410}{42356}$ ♂ yg.-ad. United States National Museum, Department of Agriculture collection. Collected August 24, 1891, by William Lloyd (original number, 694).

Measurements (taken in flesh).—Total length, 220; tail vertebræ, 60; hind foot, 36. In 8 adults from the type locality the tail vertebræ vary from 55 to 75 mm. and the hind foot from 35 to 38 mm.

General Characters.—*S. annectens* is about the size of *S. spilosoma major*, which it resembles in coloration and markings, though the pelage has a grayish cast suggesting *S. obsoletus.* Ear a mere rim, about 3 mm. high at highest point.

Color.—Upper parts dull grayish brown; back beset with ill-defined buffy spots, margined posteriorly with dusky in unworn pelage; under parts soiled white. Eyelids white. Tail concolor with back or a little more fulvous, its distal half or two-thirds bordered with a subapical black band beyond which the tips of the hairs are buffy-ochraceous. Immature specimens and young of the year are more brownish than the adults and show the spots much more distinctly, as usual in the *spilosoma* group.

Cranial and Dental Characters.—Compared with *S. spilosoma major*, the skull of *S. annectens* is longer, but is actually as well as relatively narrower across the zygomatic arches, particularly anteriorly, where the anterior roots are pinched in as in *Ictidomys;* frontals broader interorbitally; fronto-nasal region more

convex; supraorbital foramina usually completely inclosed; postorbital processes more strongly decurved; audital bullæ smaller; postzygomatic notch almost obsolete; rostrum broader across the base, with the lateral angle less marked. Under jaw larger and heavier, with posterior edge of inflected angular process broader, shorter, and less transverse. The cranium as a whole is narrower and higher than in any known member of the subgenus *Xerospermophilus*.

The dentition is unusually heavy for the subgenus, and the crown of the last upper molar is about as long antero-posteriorly as transversely. The first upper premolar is about one-third the size of the second. In all of these respects, except the character of the angular process of the mandible, the cranial peculiarities of *S. annectens* depart from the *S. spilosoma* type and resemble the *S. mexicana* type.

General Remarks.—Fourteen specimens of this animal are in the Department collection, 13 from Padre Island, Texas, and 1 from the mainland at the mouth of the Rio Grande. Padre Island is a long spit of sand in the Gulf of Mexico just north of the mouth of the Rio Grande.

Spermophilus beecheyi fisheri subsp. nov.

FISHER'S GROUND SQUIRREL.

Type from KERN VALLEY, CALIFORNIA (25 miles above Kernville). No. $\frac{29318}{41385}$ ♂ ad. United States National Museum, Department of Agriculture collection. Collected July 6, 1891, by Dr. A. K. Fisher (original number, 741).

Measurements of Type Specimen (taken in flesh).—Total length, 415; tail vertebræ, 175; hind foot, 58.

General Characters.—Similar to *S. beecheyi*, but everywhere much paler; sides of neck and shoulder-stripes clear silvery white, in striking contrast with the color of the body; sides of body thickly beset with indistinct whitish spots, narrowly bordered with dusky posteriorly. (In true *beecheyi* the spots are much less numerous, less distinct, and tend to run together so as to form irregular transverse bands.) Ear stripe not sharply defined and not so pure black as in *beecheyi*; eyelids and lower part of face whitish; under parts and feet buffy.

General Remarks.—This large ground squirrel is by far the most striking and handsome of the subgenus *Otospermophilus*, and I take pleasure in naming it in honor of one of the naturalists of the Death Valley Expedition, Dr. A. K. Fisher, who col-

lected the type specimen. Numerous specimens were obtained by the expedition in Kern Valley, Walker Pass, Owens Valley, and in the Coso, Argus, and Panamint Mountains, California.

Spermophilus chrysodeirus brevicaudus subsp. nov.

SAN BERNARDINO SPERMOPHILE.

Type from San Bernardino Peak, California. No. 56661 ♀ ad. United States National Museum, Department of Agriculture collection. Collected October 9, 1893, by J. E. McLellan (original number, 274).

Measurements of Type Specimen (taken in flesh).—Total length, —; tail vertebræ, —; hind foot, —.

General Characters.—Similar to *S. chrysodeirus*, but with much shorter tail, somewhat shorter hind foot, and duller mantle over head and shoulders. The tail averages about 75 mm., while that of *chrysodeirus* averages 90 mm. or more.

Color (of type specimen).—Back and rump grizzled gray tinged with brownish; sides paler; a dull fulvous mantle over head and neck, hardly reaching shoulders; color of head shading toward brick-red; sides of neck behind ears buffy-ochraceous; a broad whitish stripe, bordered on each side by a broad black stripe, extends from the shoulder to the rump on each side, and the white reaches beyond the black in both directions; hind foot dull whitish; tail above, proximal half grizzled; distal half black, edged with fulvous; tail below, chestnut, bordered with black and edged with fulvous.

Number of specimens examined, 7; all from San Bernardino Mountains, California.

Tamias panamintinus sp. nov.

PANAMINT CHIPMUNK.

Type from Panamint Mountains, California (between Death Valley and Panamint Valley). Exact locality, Johnson Cañon. No. $\frac{27603}{39702}$ ♂ ad. United States National Museum, Department of Agriculture collection. Collected by E. W. Nelson April 3, 1891 (original number, 723).

Measurements of Type Specimen (taken in flesh).—Total length, 208; tail vertebræ, 96; hind foot, 31. Ear from notch, 16 (measured in dry skin). Average measurements of 50 adult specimens from type locality: total length, 208; tail vertebræ, 90.4; hind foot, 31.

General Characters.—About the size of *T. quadrivittatus*, but resembles *T. speciosus* much more closely in coloration, being a paler form with obsolescent facial stripes and less distinct dorsal stripes, which are shorter posteriorly, leaving the rump clear gray. Ears smaller than in *speciosus;* ear stripes nearly obso-

lete. Tail rich orange-rufous both above and below and only narrowly margined with black. Hind foot shorter than in any other member of the *speciosus* group.

Color.—Winter pelage: Top of head and rump ash gray; back of neck and inner pair of dorsal light stripes pale vinaceous drab, fading into gray posteriorly; dorsal stripes short, not continuing over rump; outer pair of light stripes dull whitish; all five dark dorsal stripes dull fulvous; sides gray, washed with buffy ochraceous. Face stripes indistinct; those below the eye obsolete. *Tail:* upper surface rich orange rufous (from the broad sub-basal zone of this color), which is only heightened by the narrow subapical zone of black and the yellowish tips of the hairs; under surface deep orange rufous, with a narrow submarginal band of black, bordered with yellowish.

Summer Pelage: Similar to winter pelage, except that the sides and dark dorsal stripes are suffused with ferruginous, and the median part of the central stripe is blackish posteriorly.

Cranial Characters.—Skulls of *T. panamintinus* resemble those of *T. quadrivittatus* from the type locality in Colorado so closely that the two are hardly distinguishable, though the skull of the Panamint animal is slightly smaller and more depressed in the fronto-nasal region, and has larger audital bullæ. Contrasted with *T. speciosus*, the brain case is flatter and the audital bullæ conspicuously larger.

General Remarks.—In winter pelage *panamintinus* differs from *speciosus*, the only form with which it requires comparison, in having all of the stripes less distinct, particularly those of the face and ears; the dorsal stripes shorter, not running back over the rump, which is clear gray; the outer pair of white stripes narrower, shorter, and less pure white; the dark dorsal stripes pale fulvous instead of dark umber; the shoulders and back of the neck suffused with buffy-ochraceous instead of being gray, and the rufous of the distal half of the tail not obscured by black.

In summer pelage it resembles *speciosus* much more closely, but may be distinguished by less vivid tints, paler facial stripes, narrower outer dorsal white stripe, obsolescent ear stripes, pale gray rump, and by the small amount of black on the tail. In all pelages the black on the tail is very much restricted, permitting the rufous to show through on the upper surface for its entire length, thus imparting to it a peculiar ruddy glow not seen in any other species.

Geographic Distribution.—Tamias panamintinus is an inhabitant of the desert ranges of the west side of the Great Basin in California and Nevada, where 110 specimens were obtained by the Death Valley Expedition.

Tamias callipeplus sp. nov.

MOUNT PIÑOS CHIPMUNK.

Type from summit of MOUNT PIÑOS, VENTURA COUNTY, CALIFORNIA. No. $\frac{31299}{43164}$ ♂ yg.-ad. United States National Museum, Department of Agriculture collection. Collected by E. W. Nelson October 20, 1891 (original number, 1344).

Measurements of Type Specimen (taken in flesh).—Total length, 212; tail vertebræ, 92; hind foot, 33.5. Average measurements of four specimens from type locality: total length, 210; tail vertebræ, 91.7; hind foot, 34.

General Characters.—Agrees with *speciosus*, its nearest relative, in size, proportions, and pattern of markings, including the great breadth of the outer white dorsal stripe. It differs from *speciosus* in having the thighs and rump yellowish instead of gray, the back of the neck and inner pair of light dorsal stripes vinaceous-drab instead of gray; the post-auricular patches larger, purer white, and more sharply defined, and the black on the tail much less extensive. Ears large.

Color.—Winter pelage: No gray anywhere; top of head, back of neck, and inner pair of light dorsal stripes vinaceous drab, tinged with ochraceous on the shoulders, becoming fulvous on the flanks, and yellowish on the thighs and rump; outer white stripes very broad (as in *speciosus*) and slightly obscured posteriorly by dark-tipped hairs; median dorsal stripe dark umber-brown, bordered and obscured by rusty; inner pair of dark stripes ferruginous; outer pair fulvous, not defined below, passing into fulvous of flanks; post-auricular spots large, sharply defined, and pure white; ear stripes sharp, the posterior pure white, the anterior black, edged in front basally with rusty; facial stripes intensely colored and sharply defined, the middle or orbital stripe black, becoming rusty at the base of the ear; feet faintly washed with fulvous; tail orange rufous, broadly tipped and narrowly bordered with black, and edged with yellowish; the rufous obscured on upper surface by black subapical and yellowish apical zones on the hairs; belly and throat pure white, the dark basal color showing through in places.

Cranial and Dental Characters.—No cranial characters of importance have been discovered, though the brain case is slightly

more arched in the posterior frontal region than in *speciosus*. The molariform teeth are somewhat heavier, and the last upper molar has the heel more developed.

General Remarks.—*Tamias callipeplus* differs from both *speciosus* and *panamintinus* in having the hinder parts of the body yellowish instead of gray, and in the purer white and larger size of the post-auricular spots. It agrees with *panamintinus* and differs from *speciosus* in the vinaceous tinge of the back of the neck and inner pair of pale dorsal stripes, and in the color of the tail. It differs from *panamintinus* and agrees with *speciosus* in the brightness and sharpness of the facial stripes and ear stripes, the great breadth of the outer pair of dorsal white stripes, in the posterior extension of the dorsal stripes over the rump, and in the large size of the hind foot.

Tamias callipeplus is treated as a full species instead of a subspecies on account of its isolated geographic position, intergrades being impossible because the mountains on both sides of Mount Piños do not attain sufficient altitude to provide the cool temperature required by the species.

Tamias alpinus sp. nov.

ALPINE CHIPMUNK.

Type from Big Cottonwood Meadows, High Sierra, California, just south of Mount Whitney (altitude, 3,050 meters or 10,000 feet). No. $\frac{30597}{42491}$ ♀ yg.-ad. United States National Museum, Department of Agriculture collection. Collected by Basil Hicks Dutcher August 12, 1891 (original number, 191).

Measurements of Type Specimen (taken in flesh).—Total length, 189; tail vertebræ, 82; hind foot, 29. Ear from notch, 13 (in dry skin). Average measurements of 15 specimens from type locality: total length, 185; tail vertebræ, 79; hind foot, 29.3.

General Characters.—Size, small; resembles *T. minimus pictus* in size, proportions, and general appearance, but is much paler in breeding pelage and much more ferruginous in midsummer pelage; may be distinguished from *pictus* in all pelages by the tail, which is much broader and more bushy, hoary above, and broadly tipped with black both above and below.

Color.—*Fall pelage:* General color of upper parts, hoary gray, suffused on the flanks with buffy-ochraceous; median dorsal stripe dusky, obscured by pale rusty; lateral dorsal dark stripe pale ferruginous; inner pair of white stripes hoary gray; outer pair white and very broad (as in *speciosus*); post-auricular

patches whitish, not sharply defined; facial stripes pale; ear stripes indistinct; legs and feet gray. Tail: upper surface hoary (rarely yellowish), becoming black toward the tip (the individual hairs buffy gray sub-basally, then black, and broadly tipped with pale buffy gray or yellowish); under surface, pale buffy fulvous, bordered and broadly tipped with black, broadly edged laterally with pale buffy.

Summer Pelage: Dorsal dark stripes bright ferruginous; facial stripes strengthened by dull rusty; flanks bright fulvous, the fulvous reaching forward over shoulders to sides of neck.

Cranial Characters.—Skull similar in size and general appearance to that of *T. minimus pictus*, but with longer nasals and nasal branches of premaxillaries. The length of the nasals equals or exceeds the combined length of the basioccipital and basisphenoid. In *minimus* the nasals fall considerably short of this measurement.*

General Remarks.—The Alpine chipmunk is one of the two smallest chipmunks known, the other being the Sage Plains species (*T. minimus*), which it resembles in general appearance, except in the full summer pelage. In all pelages it may be distinguished from *minimus* by the tail, which is hoary above (rarely yellowish); is broader and more bushy, and has the black terminal part much longer. The outer pair of white dorsal stripes also are much broader, as in *speciosus*. In spring and early summer, before the post-breeding molt, the animal is very much paler than the palest specimens of *minimus pictus*. In midsumer pelage, on the other hand, the sides and dark stripes are deeper ferruginous than ever seen in the brightest summer specimens of *minimus pictus* or even *minimus consobrinus*, and in high-colored individuals even the inner pair of light stripes are sometimes obscured by rusty.

Geographic Distribution.—This beautiful little chipmunk is restricted, so far as known, to the alpine summits of the High Sierra, where it lives among rocks at timber-line, ranging a little above and a little below the upper limit of tree growth. Thus the haunts of the alpine chipmunk are the same as those of the pika (*Lagomys*), the alpine marmot (*Arctomys flaviventer*), and the mountain sheep (*Ovis canadensis*). No mammal ranges higher. Sixty specimens were obtained by the Death Valley Expedition.

*This has been verified in 100 skulls, 50 of *alpinus* and 50 of *minimus* and subspecies.

VOL. VIII, PP. 139-142 DECEMBER 28, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

DESCRIPTION OF A NEW SPECIES OF *ARVICOLA*, OF THE MYNOMES GROUP, FROM ALASKA.

BY E. W. NELSON.

Arvicola operarius sp. nov.

THE TUNDRA MOUSE.

Arvicola riparius borealis Nelson and True, Report upon Natural History Collections in Alaska, 1887, pp. 275, 276, Series A (not Richardson).

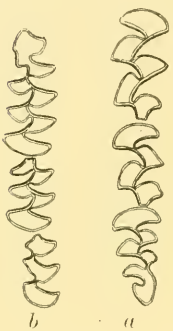
Type No. $\frac{14378}{2225}$. United States National Museum. From St. Michaels, Norton Sound, Alaska. November, 1879. Collected by E. W. Nelson.

Measurements.—Average measurements, in millimeters, of five dried skins, fall and winter specimens, from St. Michaels are as follows: Total length, 104.5; length of tail vertebræ, 25.2; hind foot, 17.9; ear from front base, 9.8.

Color.—The dorsal surface, including the top and sides of the head, is pale, dull fulvous or fawn color, thinly washed with darker from the overlying black tips of the long hairs. On the sides the fulvous of the back shades gradually into the paler lower surface and sometimes forms a faint wash over most of the under parts. The top of the tail is dark brown, in contrast with the color of the back, and its sides and lower surface are white. The under surface is plain, dull, grayish white, including upper lips, chin, and throat, and extending laterally to the insertion of the legs. In some cases the white area is separated from the white under surface of the tail by a narrow band of fulvous

which incloses the base of this member below. The feet and legs are dull whitish. The fur is long and very soft, except on the tail. The tail hairs are rather coarse and stiff and the terminal pencil is peculiarly bristly with a length of 6 mm.

The ears are rounded and clothed on the inner side of conch by yellow hairs. They are wholly concealed by the fur.



b *a*

Molar teeth of *Arvicola operarius* x 5.

a, upper; *b*, lower.

The under fur, with basal two-thirds of the long hairs, is of a uniform dark slaty color; succeeding the dark base the majority of the long hairs of the back have a plain fulvous tip. The tips of the longest hairs, however, are black, succeeding a yellowish zone, thus producing a slight wash of darker over the back.

A slight variation in color is apparent among the specimens, due to the varying intensity of the fulvous. The soles of feet are naked. The thumb nail is short, stout, and spatulate and does not extend beyond end of the thumb.

Dentition.—The accompanying figure shows the pattern of the crowns of the molar teeth.

Skull measurements of five specimens of *Arvicola operarius* from St. Michaels, Alaska:

U. S. National Museum numbers..	22225	22212	22224	22214	22223
Basilar length of Hensel.....	21.	21.	21.	21.	20.75
Greatest zygomatic width.....	12.5	12.5	12.5	12.75	12.5
Interorbital constriction.....	3.5	3.5	3.5	3.25	3.5

The present species may be readily distinguished from any known American *Arvicola* by its smaller size and pale fulvous color. It is very abundant along the coast tundras of Bering Sea from Cape Vancouver north at least to Bering Straits, including Nelson, St. Michaels, and Stewart Islands. It makes numerous runways through the moss and under the grass in all the tundra districts where it lives, and as winter approaches gathers stores of small bulbous roots, sometimes placing a peck or more in a single cavity just below the surface on a mossy knoll or slope.

For a short period before the first snowfall in autumn the Eskimo women and children search for these stores with pointed sticks, which they thrust into the sides of mossy banks in suitable places, the spot being found by the ease with which the stick penetrates the few inches of mossy cover. In this way considerable quantities of this food are gathered, and during the following winter it is boiled and eaten as a delicacy. The boiled roots have a flavor like a boiled unripe sweet potato and are very palatable during the long winter fare of meat and fish. During seasons when the snow remains on the ground from fall until spring, comparatively few of these mice come about the houses until the snow begins to melt in spring, when they always become numerous there.

A winter thaw occurs at intervals of several years, melting away nearly all of the snow. At such times the water percolates into all of their runways and storehouses, and the quickly succeeding cold freezes them solid for the remainder of the season. In this way the majority of these mice are at once bereft of shelter and food, and are found wandering about on the surface of the tundras, where many are eaten by foxes and other animals, while others freeze to death, and scores swarm about the native villages and the fur-trader stations.

Ordinarily in spring, as the snow melts away, many winter burrows are revealed just at the lower surface of the snow. Their burrowing can never extend very deep in many places where the permanently frozen soil lies at a depth of from one to two feet. On a dry peat knoll fronting the sea near St. Michaels I once followed their holes to a depth of about two feet.

The Eskimo boys trap them in toy traps modeled after those used by the men for larger game, and the children use their skins for blankets and clothing for dolls.

These mice are omnivorous, and when two or more are confined together in a box the stronger usually kill and partly devour the weaker.

Through the kindness of Dr. C. Hart Merriam I am able to present herewith a plate showing the character of the dentition of this species. I wish also to acknowledge herein my indebtedness to the courtesy of Mr. F. W. True, Curator of Mammals in the United States National Museum, who kindly placed the specimens of the Alaskan *Arvicolæ* at my disposal.

VOL. VIII, PP. 143-146 DECEMBER 29, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

PRELIMINARY DESCRIPTIONS OF FOUR NEW MAMMALS FROM SOUTHERN MEXICO, COLLECTED BY E. W. NELSON.

BY C. HART MERRIAM, M. D.

Lepus orizabæ sp. nov.

MT. ORIZABA COTTONTAIL.

Type from MT. ORIZABA, STATE OF PUEBLA, MEXICO (altitude about 9,500 feet). No. 53318 ♀ ad. United States National Museum, Department of Agriculture collection. Collected April 24, 1893, by E. W. Nelson (original number, 4730).

Measurements of Type Specimen (taken in flesh).—Total length, 395; tail vertebræ, 51; hind foot, 90.

General Characters.—Similar to *L. arizonæ* in general appearance and length of ear, but very much darker and differing considerably in color; pectoral band broad and full, forming a distinct ruff.

Color.—Head, back-saddle, and thigh streaks grizzled buffy clay-color and black, the admixture of black plentiful and uniform; flanks and rump mixed gray and black, the gray particularly clear on rump; upper side of tail grizzled drab-gray, with tips of hairs buffy; nape patch and fore and hind feet, dull

fulvous, palest on inner sides of hind feet; pectoral collar drab, with tips of long hairs buffy; chin, throat, middle of belly and under side of tail, pure white with under fur plumbeous except under tail, where the fur is white throughout; ears dull grayish brown, bordered apically with a brown band, which is not very well defined; anterior edge fringed with whitish.

Cranial Characters.—Skull similar to that of *L. arizonæ*, but with audital bullæ much smaller.

Sciurus nelsoni sp. nov.

NELSON'S SQUIRREL.

Type from Huitzilac, Morelos, Mexico. No. 51157 ♀ ad. United States National Museum, Department of Agriculture collection. Collected January 1, 1893, by E. W. Nelson (original number, 4144).

Measurements of Type Specimen (taken in flesh).—Total length, 500; tail vertebræ, 246; hind foot, 68. Average measurements of 4 specimens from type locality: Total length, 527; tail vertebræ, 262; hind foot, 70.

General Characters.—Premolars $\frac{2}{1}$; size large, about equaling *S. cervicalis;* color of upper parts uniform. No trace of nuchal patch or rump patch.

Color.—Type Specimen: Upper parts from nose to tail grizzled yellowish brown; under parts grizzled fulvous, purest on throat and breast, much mixed with black posteriorly; end of nose, ears, and feet black, the feet (both fore and hind) more or less grizzled (probably a seasonal character, as the feet are wholly black in most of the specimens); tail black; upper side with tips of hairs whitish; under side bordered with whitish. Below the broad subterminal black zone there is a concealed zone of dull fulvous.

Other Specimens.—Some specimens are much darker than others, and the difference seems to be seasonal. In some the head, feet, and legs are intense black. The feet are almost wholly black in nearly all the 14 specimens, and the under parts are usually blacker than in the type. The tail is usually black, washed above and on the sides with whitish, but in some specimens the under side is grizzled from admixture of black and dull buffy-gray. Two or three of the specimens show a whitish spot (usually rather indistinct) at the posterior base of the ear.

Specimens examined, 14: 4 from Huitzilac, Morelos; 9 from Ajusco, Mexico, and 1 from Salazar, Mexico.

Thomomys orizabæ sp. nov.

MT. ORIZABA THOMOMYS.

Type from Mt. Orizaba, State of Puebla, Mexico (altitude, about 9,500 feet). No. 53616 ♀ ad. United States National Museum, Department of Agriculture collection. Collected April 25, 1893, by E. W. Nelson (original number, 4744).

Measurements (taken in flesh).—Type specimen: Total length, 217; tail vertebræ, 68; hind foot, 30. Average measurements of 13 specimens from type locality: total length, 213; tail vertebræ, 66; hind foot, 29.

General Characters.—Size medium; sooty-plumbeous phase dominant; fulvous phase resembling *T. fulvus*, but duller. Tail longer than in *T. fulvus;* well haired; fore and hind feet well haired.

Color.—Plumbeous phase (the type and 15 out of a total of 17 specimens from type locality are in this phase): Everywhere uniform slate-black (faintly paler below) except distal part of fore and hind feet, distal third of tail, and inside of cheek pouches, which are white (sometimes also a few white hairs about mouth and under chin). The color of the body always passes down over the wrists and ankles and usually reaches half way to the toes—sometimes further.

Fulvous phase: Upper parts dark umber-brown, becoming dusky on nose and dull fulvous on sides; under parts buffy-fulvous, the plumbeous basal fur showing through in places; under side of face blackish; feet and distal third of tail white. (Only 2 specimens, one of which is very young, out of a total of 17, are in this pelage.)

Cranial Characters.—The skull of *T. orizabæ* differs from that of *T. peregrinus* here described (the only species thus far recorded from southern Mexico) in the following particulars: Muzzle longer and much broader; frontals anteriorly much broader; ascending branches of premaxillæ much broader and blunter posteriorly. The breadth of muzzle across ascending branches of premaxillæ, and breadth of frontals anteriorly, is considerably greater than the interorbital breadth; in *peregrinus* the contrary is true.

Thomomys peregrinus sp. nov.

WANDERING THOMOMYS.

Type from SALAZAR, STATE OF MEXICO. No. 50130 ♀ yg.-ad. United States National Museum, Department of Agriculture Collection. Collected October 23, 1892, by E. W. Nelson (original number, 3668).

Measurements (taken in flesh.)—Type specimen: Total length, 207; tail vertebræ, 72; hind foot, 28.5. Average measurements of 10 specimens from type locality: Total length, 201; tail vertebræ, 57; hind foot, 28.

General Characters.—Similar to *T. fulvus*, but much darker and duller, lacking the bright golden-fulvous tints of that species, and differing also in cranial characters. The incisors curve far forward.

Color.—Upper parts dark umber-brown, becoming sooty-black on head and along middle of back, and dull fulvous on sides; end of nose, broad ring round mouth, and ear-patches blackish; under parts buffy, the plumbeous basal fur showing through; toes of fore feet, most of hind feet, and distal ⅓ or ½ of tail white. On the hind feet the dark color of upper parts reaches down over ankles; on fore feet it usually comes down to or near bases of toes.

Cranial Characters.—Compared with *T. orizabæ* the muzzle is very narrow, the breadth across ascending branches of premaxillæ being much less than the interorbital breadth. The frontals anteriorly are also considerably narrower than interorbitally, and the premaxillæ are slender and pointed posteriorly. In young and middle-aged skulls the interparietal is straight posteriorly, broadly rounded anteriorly, and nearly twice as broad as long; in old skulls it is roughly subquadrate.

VOL. VIII, PP. 147-152 DECEMBER 29, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

THE YELLOW BEAR OF LOUISIANA, *URSUS LUTEOLUS* GRIFFITH.

BY C. HART MERRIAM, M. D.

Ursus luteolus Griffith, Order Carnivora, 1821, 236–237, with colored plate.
Ursus americanus Baird, Mammals of North America, 1857, 217 and 222 (in part—*not* of Pallas).
Ursus cinnamomeus Brown, Forest and Stream, December 16, 1893, 519 (in part—*not cinnamomum* of Audubon and Bachman).

In the year 1800 Shaw mentioned and in part described a yellow bear from the southern United States, but did not give it a specific name, referring it to the black bear as a variety, with a query. His account in full is as follows: "Yellow bear. Among Mr. Catton's figures of quadrupeds a representation is given of a yellow bear from the living animal then kept in the Tower. The following is the description accompanying the plate referred to: 'The yellow bear from Carolina (as the American bears in general are) is rather smaller than the European bears; it has also a more pleasant and agreeable countenance, is perfectly tame and sociable; the color a lively, bright orange, of a reddish cast; the hair thick, long, and silky. Its other properties are the same as of the species in general.'" (General Zoölogy, vol. I, part II, Mammalia, 1800, p. 454.)

In 1821 Edward Griffith, in his important and rather rare work on the Carnivora, named this bear *Ursus luteolus*, and gave

a colored plate of it. His description is as follows: "Yellow bear. *Ursus luteolus.* The American yellow bear has been spoken of as a variety of the black bear of that continent. Independently of the individual mentioned in Shaw's Zoölogy, Major Smith has a drawing of one, taken in Louisiana,* and there is a fine specimen now in the Tower, which is aptly called. from its color, the cinnamon bear. This last is smaller; the forehead more convex; the nose more conical than in the black species; the ears also stand farther back; the physiognomy may be said to be more fox-like, and the hair is not so long or thick. It is gentle in disposition, which, indeed, is expressed in the countenance of the animal very decidedly. We cannot, therefore, but conclude that the hereditary distinctive differences of color, organization, and moral character are quite sufficient to constitute this a separate species.

"The yellow bear was formerly common in Virginia, and is still frequently met with in northwestern Louisiana, where it is called the white bear, and seems generally, though without doubt erroneously, to be considered an accidental variety, the offspring of the black bear. It subsists on honey, acorns, &c., as well as flesh." (Descriptions of Vertebrated Animals, Order Carnivora, London, 1821, 236–237, and col. pl.)

Six years later, in the mammal part of his well-known edition of Cuvier's *Animal Kingdom*, Griffith reluctantly treats the species as a variety of the American black bear, saying: "The Baron [Cuvier] also thinks that the yellow bear of Carolina is a variety of the same species. This is scientifically termed the *Ursus luteolus.* We shall not venture to assert, in contradiction to the authority of the Baron, that this bear forms a distinct species, but assuredly it is a very strongly marked variety. * * * They were formerly common in Virginia, and they are still abundant in northwestern Louisiana, where they are called white bears, and are said to feed chiefly on honey, on acorns of a large size, wild berries, &c." (Griffith's Cuvier, Mammalia, II, 1827, 228–229.) Whether or not two distinct bears were confounded in the original description is of little conse-

* Lest any one should suppose that the old Territory of Louisiana, stretching westward to the Rocky mountains, was meant, it may be stated that the present boundaries of Louisiana were fixed in 1812, nine years before the publication of Griffith's original description and fifteen years before his second.

quence, the fact remaining that Griffith's *Ursus luteolus* was based primarily upon the Louisiana animal—figured by Major Hamilton Smith; hence his name must hold for the species if it is found distinct from the common black bear of the eastern United States (*Ursus americanus*).

When engaged upon a revision of the North American bears some time ago I was struck by certain cranial and dental peculiarities possessed by five skulls* from Prairie Mer Rouge, Morehouse parish, Louisiana, which led me to regard the species as very distinct from the two species now commonly recognized as inhabiting the United States, namely, *Ursus americanus* Pallas and *U. horribilis* Ord. Owing to the absence of skins of this animal, and the rather scanty material illustrative of several other points concerned in a proper elaboration of the group, publication of the review in question was deferred. The recent appearance of an article by Mr. Arthur Erwin Brown,† superintendent of the Zoölogical Garden at Philadelphia, in which this remarkable bear is in part described, though wrongly referred, makes it desirable to issue a preliminary description of the species, based on the meager material now in hand. The following description is based wholly on the skulls from Mer Rouge, Louisiana, of which No. 1155 may be regarded as the type.

Cranial Characters.—Skull long and flat; fronto-parietal region depressed; profile of top of skull (including crest) nearly a straight line; sagittal crest long and high, about half the length of upper side of skull in old age. Contrasted with old skulls of male black bears from the Adirondacks, in northern New York, the three old male skulls from Mer Rouge, Louisiana, differ uniformly in the following particulars: They are longer and flatter; the occipito-sphenoid length ‡ is greater; the distance from foramen magnum to plane of front of last upper molar is greater; the ratio of zygomatic breadth to basilar length is less; the ratio of postpalatal length § to occipito-sphenoid length is considerably greater.

---

*These skulls have been in the United States National Museum many years and some of their peculiarities were mentioned by Baird in his great work on the Mammals of North America in 1857.

† Forest and Stream, New York, Dec. 16, 1893, 518–519.

‡ Occipito-sphenoid length—distance from anterior lip of foramen magnum to suture between basisphenoid and presphenoid.

§ Post-palatal length—distance from anterior lip of foramen magnum to post-palatal notch.

The largest of the three old male skulls from Mer Rouge, Louisiana (No. 1155 United States National Museum), affords the following measurements: Basal length (basion to front of premaxilla), 292; basilar length of Hensel, 288; zygomatic breadth, 187; occipito-sphenoid length, 89; postpalatal length, 134; distance from inferior lip of foramen magnum to plane of front of last upper molar, 193; interorbital breadth, 68; distance between postorbital processes, 97; occipito-nasal length, 276; greatest length of skull, 326.

Dental Characters.—Molars larger than in any known species of the black bear group (subgenus *Euarctos* Gray); last upper molar in particular very large and notable for its great breadth as well as length, measuring 30 by 17 mm. in an old male from Prairie Mer Rouge (No. 1155), and doubtless larger in early life, as the tooth is much worn; the first upper molar in the same specimen measures 19.5 by 15.7 mm. The fourth lower premolar is tuberculate, having distinct cusps on the cingulum both anteriorly and posteriorly.* The latter is notched in the middle longitudinally, giving it a double crown. In addition to these cusps, one of the females with less worn teeth than the others has a small but distinct peg-like projection rising from the cingulum on the inner side near the middle, and closely pressed against the main cusp, from which it projects only slightly. But this tooth is subject to so much individual variation in bears from the same locality that it would be unsafe to place any reliance on the peculiarity here described unless it is found to hold good in a larger number of individuals than are now available for comparison. Traces of it exist, however, in the other female from Prairie Mer Rouge (No. 988), which is older and has the teeth more worn.

Color.—The name 'yellow bear' given to this species by Shaw and Griffith points to a marked peculiarity of coloration, and Mr. Arthur Erwin Brown, in his interesting article already referred to, describes one of his specimens as "flaxen color, with traces of a darker shade on the nape." The skull and teeth of this specimen are not described, but the inference is that they agree with the Ozark skull. Another bear, believed by Mr. Brown to be this species, is described as follows: "The color of

* Black bears from the Adirondacks and various other places often have a distinctly tuberculate crown to the tooth in question (pm_4), but they lack the other peculiarities mentioned.

the specimen now living [in the Philadelphia Zoölogical Garden] is in autumn a rich reddish brown, almost bay. As his coat becomes worn and faded he becomes pale yellowish brown, the color being generally uniform over the body."* This bear was presented to the garden by the late General James S. Brisbin, then stationed at Omaha, Nebraska, from which circumstance Mr. Brown infers that it came from the Rocky Mountain region—an inference that hardly seems safe, particularly if the animal really proves to be *U. luteolus*. On the other hand, it is by no means certain that *luteolus* is always yellow; and if I were to hazard a conjecture, in view of what little is known on the subject, it would be to the effect that the normal color is black.

Geographic Distribution.—Very little is known of the geographic distribution of this bear further than the fact that it inhabits Louisiana. It may be found to range over much of the lowlands of the Gulf and South Atlantic states, and to intergrade with the black bear of the mountains of Tennessee and the Carolinas. A semi-fossil skull from the bed of an old stream near Fort Worth, Texas, examined by me, and the skull found by Professor Cope in a cave in the Ozark hills, in southern Missouri, recently described by Mr. Arthur E. Brown, may belong to an ancestor of this species rather than the species itself.

The name *cinnamomum* of Audubon and Bachman † cannot be applied to this species, because *luteolus* has thirty-three years' priority, and also because *cinnamomum* was based on an animal from the northern Rocky mountains, which has small molars, like the common black bear of the northeastern United States.

*Forest and Stream, December 16, 1893, 518.

† *Ursus americanus* var. *cinnamomum* Audubon and Bachman, Quadrupeds of North America, vol. iii. 1854, 125–127.

ALPHABETICAL INDEX.

A.

PAGE

Acanthoceras (?) justinæ....17, 38
Adeorbis....101
Alucita kellicottii....52
Ammonites (Bachiceras) pedernalis....102
(Schloenbachia) acute-carinatus....102
Ammospermophilus....129, 130, 131
Anazyga....78
Ancylobrachia....72, 73, 77
Anomia texana....16, 22
Araucarites....40
Arctomys flaviventer....138
Arthropoda....17, 39
Arvicola emmonsii....60
operarius....139
riparius borealis....139
Ashmead, Wm. H., elected....xii
Athyridæ....76
Atretia....81
Atrypa....76
reticularis....77
Atrypidæ....76, 77

B.

Bailey, Vernon, The Burrows of Five-toed Kangaroo Rats....vii
Baker, Frank, Recent Discoveries in the Nervous System....vii
——Remarks....iv, v, vii, xiii
Bangs, Outram, elected....vii
Barbatia parv amissouriensis....16, 26
Bassaris....89
Bean, T. H., remarks....iv, xiii
Bear, Yellow....147, 150
Beecher, Charles E., Development of the Brachial Supports in Dielasma and Zygospira. By Charles E Beecher and Charles Schuchert....71
Blodgett, F. H., Notes on the Development of the Bulb of the Adders' Tongue....xiii
Brachial supports....71
Brown, Herbert, elected....vii
Buccinopsis (?) parryi....17, 33
Burgess, E. S.,....xi, xiii
Burroughs, J.,....viii

C.

Calliostoma....101
Camarella....80
bisculata....80
Caprina limestone....97, 98, 100, 104
Cardium (?) severese....16, 29
Centronella....72, 73, 75, 81
Cerithium austinensis....102
obliterato-granosum....102
Certhia familaris americana....63
Chamidæ....100, 101, 102, 103
Chelonia....17
Chickering, J. W., The Botanical Landscape....ix
Chione (?) decepta....16, 27

PAGE

Chrysostoma....101
Cistella....81
Cladophyllia furcifera....101
Cœlosmilia americana....101
Cœlospira....76, 77
barrandei....77
marginalis....77
Coleopterous larvæ....52
Comanche series....9, 97
Cook, O. F., Notes on the Natural History of Liberia....ix
Coralliochama....100
Corbicula arkansaensis....16, 29
Cottontail, Orizaba....143
Cretaceous formations....97
Coville, Frederick Vernon, Characteristics and Adaptations of a Desert Flora....ix
——Juncus marginatus and its varieties....121
——Remarks....iv, vii, viii, x, xi, xii
Cricetus myoides....55
Crocodilia....17
Cucullæa comanchensis....16, 25
" gratiota....16, 25
" terminalis....16, 25
Cylindrites (?) sp....17, 33
Cypridea texana....17, 39

D.

Dall, Wm. H., New Forms of Fossils from the Old Miocene of the Gulf States....xi
——Remarks, etc....iv, vi, vii, viii, xi, xii, xiii
Dayia....74, 80
Dewey, L. H., Geographic Distribution of Grasses in the United States....x
navicula....74
Diceras (?)....103
Dielasma....71, 72, 73
turgida....71, 73, 77
Dinosauria....17
Diplostoma (?) bulbivorum....113, 114
Dipodomys....83, 85, 90, 95, 96
californicus....91, 92
merriami....91, 92, 95, 96
phillipii....83, 90
phillipsi 83, 84, 86, 87, 89, 91, 92, 93, 95, 96
phillipsii....83, 91, 95
spectabilis....95
Doran, E. W., Development of the Intestines of Tadpoles....viii
Doubleday, H. H., elected....v

E.

Echinodermata....16, 21
Epiaster (?) sp....16, 21
Eriphyla pikensis....16, 28
Evans, Walter H., elected....v
——Remarks....ix
Everman, Barton W., The Ichthyologic Features of the Black Hills....x
——Remarks....vi, vii, xi

F.

PAGE
Fairchild, D. G., Notes on Apple and Pear Fusieladii.....v
Fernow, B. E., Remarks, etc.....iv, xii, xiii
——What are the Special Needs of the Biological Society of Washington.....xii
Foraminifera.....16, 20
Fredericksburg division.....10, 11

G.

Galloway, B. T.,.....xiii
Gerboa.....89
Gill, T.,.....iv, vii, ix, xi xii, xiii
Glauconia (?).....102
Goniolina.....40
Goode, G. B.,.....iv, xiii
Gurley, R. R., Natural Selection as exemplified by the Cackling of Hens.....ix
Gwynia.....81

H.

Hadena stipata.....52
Hallina.....72, 74, 78, 82
nicoletti.....74
saffordi.....74
Hallock, Charles, The Geographical Distribution of the Musk-Ox.....vi
Hammond, W. A.....vii
Hasbrouck, E. M., The Breeding of the Bald Eagle near Mt. Vernon.....viii
——The Development of the Appendages of the Cedar Wax-wing.....vii
Helicocryptus.....101
Helicopegmata.....73, 76, 77
Hesperomys.....
campestris.....60
gracilis.....61
leucopus.....57, 58
manicalatus.....60
myoides.....55, 59, 62
Hesperoyucca.....42
Hill, Robert T., Notes on the Paleontology of the Comanche Series.....v
——Paleontology of the Cretaceous Formations of Texas. The Invertebrate Paleontology of the Trinity Division.....9
——The Paleontology of the Cretaceous Formations of Texas. The Invertebrate Fossils of the Caprina Limestone Beds.....97
——Remarks.....vi
Hippurites.....103, 104, 108
flabellata.....104
texanus.....108
Holcetypus.....101
Holm, T.,.....iv
Howard, L. O.,.....iv, v, viii, xi, xiii

I.

Ichthyosarcolithus anguis.....102, 103
(Caprina) erassipira...103
(?)guadalupæ.....103
(?)occidentalis.....103
(?)planata.....103
(?)texana.....103
Ictidomys.....132
Insects, Yucca.....41, 47
Isocardia (?) medialis.....16, 31

J.

PAGE
Jackson, Sheldon, The Introduction of Reindeer in Alaska.....vii
——Remarks.....vi
Jumping mouse.....1
Juncus aristatus.....123, 125, 126
aristulatus.....123, 125, 126
biflorus.....123, 126
canaliculatus.....123
heteranthos.....123, 126
cylindricus.....121, 125
marginatus.....121, 125, 126, 127, 128
" aristulatus 123, 125, 126, 127, 128
" biflorus.....123
" paucicapitatus.....125
" setosus.....126, 127
" vulgaris.....121, 125
odoratus.....123
setosus.....124, 126
Juvavella.....72

K.

Kangaroo rat.....83
" " Mexican.....83
Knowlton, F. H.....iv, xiii

L.

Lagomys.....117, 138
Lagomys collaris.....117, 118, 119, 120
princeps.....117, 119, 120
schisticeps.....119, 120
Leda (?) harveyi.....16, 25
Lepidoptera.....52
Lepidopterous larvæ.....52
Lepidotus.....17
Lepus arizonæ.....144
orizabæ.....143
Lucas, F. A., The Food of Humming Birds.....vii
——Remarks, etc.....iv, viii, ix, xiii
Luke, D. D., elected.....v

M.

McCormick, L. M., A Hybrid between Pyranga rubra and erythromelas.....viii
Macandrevia.....72
Macrocolus halticus.....91, 94, 95, 96
Mazama montana.....118
Meriones labradorius.....2
Merriam, C. Hart, Biology in our Colleges.....xi
——Descriptions of eight new Ground Squirrels of the genera Spermophilus and Tamias, from California, Texas, and Mexico.....129
——The Fauna and Flora of Eastern Wyoming.....xii
——The Four-toed Kangaroo Rats.....vi
——Preliminary descriptions of four new mammals from Southern Mexico, collected by E. W. Nelson.....143
——Re-discovery of the Mexican Kangaroo Rat, Dipodomys phillipsi Gray. With field notes by E. W. Nelson.....83
——Remarks on the Genus Geomys.....xii
——Two new Wood rats from the plateau region of Arizona (Neotoma pinetorum and N. arizonæ). With remarks on the validity of Genus Teonoma of Gray.....109

PAGE
——The Yellow Bear of Louisiana. Ursus luteolus Griffith.....147
——Remarks, etc., iv, vi, vii, viii, ix, xi, xii, xiii
——and Vernon Bailey. Notes on Biological Reconnoisance of Wyoming.....xi
Merriam, Florence A., elected.....vii
Miller, Jr., Gerrit S., A New Jumping Mouse (*Zapus insignis*).....vi
——A Jumping mouse (*Zapus insignis* Miller) new to the United States....1
——Description of a new White-footed mouse from the Eastern United States.....55
——Notes on Thomomys bulbivorus....113
Modiola branneri.....16, 24
Mollusca.....22
Molluscoidea.....16, 22
Monopleura marcida.....16, 29, 102, 103
pinguiscula.....16, 29, 102, 103
subtriquetra.....103
texana.....103
Moore, V. A., The Distribution of Pathogenic Bacteria in the Upper Air Passages of Domesticated Animals.....x
——Observations on the Distributions and Specific Character of the Streptococci Group of Bacteria....ix
See also Smith, T., and Moore.
Mus agrarius americanus.....59
bairdii.....61, 62
michiganensis.....61
noveboracensis.....59
sylvaticus.....59
" noveboracensis.....59
Musculus leucopus.....59
Mynomes.....139

N.

Natica (?) texana.....16, 32
Natica (Amauropsis) avellana.....102
Nelson, E. W., A New Species of Lagomys from Alaska.....xiii
——Description of a new Species of Lagomys from Alaska.....117
——Description of a new Species of Arvicola, of the Mynomes group, from Alaska.....139
(See also Merriam.)
Nelson's, Henry Clay, death.....viii
Neotoma.....109
arizonæ.....109, 110, 111
cinerea.....110, 112
fuscipes.....109, 111
mexicana.....111, 112
pinetorum.....109, 111
Nerinea
austinensis.....17, 36, 101
cultrispira.....101
subula.....102
Neritina sp.....17, 37
Neumayria walcotti.....17, 37
Newberria.....72
Nordqvist, Dr., a guest.....vii
——Remarks.....vii
Nucleatula.....72
Nucleospiridæ.....76

O.

Obolella.....80
Officers elected Dec. 31, 1892.....iv
Officers elected Dec. 30, 1893.....xiii
Orbitulites texana.....40
Ostrea franklini.....16, 23
joanæ.....105
munsoni.....102, 105
Otospermophilus.....133
Ovis canadensis.....138
dalli.....118

P.

Palmer, T. S.....iv, x, xiii
Parasmilia austinensis.....101
Patella.....101
Patellina texana.....16, 20
Paterina.....80
Pecten stantoni.....16, 24
Pedregal.....87
Pentamerus.....80
Perognathus.....85, 89, 95, 96
Perodipus.....89
Pholadomya knowltoni.....16, 30
" lerchi.....16, 30
Pileolus.....101
Plagioptychus (?) cordatus.....103
Plantæ.....17, 39
Pleurocora coalescens.....101
texana.....101
Pleuromya (?) henselli.....16, 31
Pollination, Yucca.....41
Pratt, F. C., elected.....xii
Prodoxids.....50, 51, 53
Prodoxus.....47, 52
cinereus.....48, 51
coloradensis.....47
decipiens.....49
intermedius.....49
intricatus.....50
reticulatus.....48, 50
Pronuba.....41, 43, 52, 53
Pronuba maculata.....41, 43, 44, 45, 46, 51, 53
synthetica.....46, 53
yuccasella.....42, 44, 45, 46, 49, 52
Protocardia sp.....16, 29
Pterophorid.....52
Pterophoridæ.....52

R.

Radiolites.....102, 104, 108
Radiolites austinensis.....100, 103
davidsonii.....102, 103, 106, 108
texana.....102, 103
Rathbun, R.....iv, xiii
Rensselæria.....72
Requiena bicornis.....103
patagiata.....102, 103
texana.....102, 103
texana (?).....16, 28
Reyburn, R.....viii
Riley, C. V., Further notes on the Yucca Inseets and Yucca Pollination.....41
——Further Notes on Yucca Pollination.....xi
——Remarks, etc.....iv, viii, x, xi, xii, xiii,
Rives, William C., elected.....viii
Rose, J. N., Two Trees of Economic Importance from Mexico.....ix
——Remarks.....xii
Rostracea.....80, 81
Roth, Filibert, elected.....xiii
Rudistæ.....103
Rudistes.....99, 100, 102

S.

Schaeffer, E. M.....xi
Schuchert, Charles, elected.....x
——Development of the Brachial Sup-

PAGE
ports in Dielasma and Zygospira. By Charles E. Beecher and Charles Schuchert. And on the Development of the shell of Zygospira recurvirostra. By Charles Schuchert....71
——Remarks....iv
Seaman, W. H....xiii
Simpson, Charles Torrey, elected....xi
Sitomys....55
americanus..55,56,57,59,60,62,63,64,65,66
arcticus....67
aureolus....62
canadensis,55,56,57,59,60,61,62,63,67,68,69
Smith, Erwin F., Additional Notes on Peach Rosette....v
——A Bacterial Disease Cucumbers, etc., working through the Fibrovascular Bundles and probably transmitted by Insects....xiii
——Peach Yellows and Plant Nutrition..x
——Remarks....iv, v, ix, x
——The Symbiosis of Stock and Graft...x
Smith, Theobald, The Bacteriology of Potomac Water and its Bearing upon Sanitary Problems....viii
——A New Sporozoon in the Intestinal Villi of the Ox....x
——Remarks....iv, ix, x, xiii
——and V. A. Moore, The Growth of Bacteria Through the Pasteur-Chamberland Filter....v
Solarium planorbis....102
Spermophilus annectens....133
beecheyi....133
beecheyi fisheri....133
chrysodeirus....134
" brevicaudus..134
elegans....131
mexicanus....131, 132
nelsoni....129
obsoletus....132
perotensis....131, 132
spilosoma....131
" annectens....132
" major....131
Sphærulites....108
Spiriferidæ....76
Stanton, T. W....iv, v, vi
Stejneger, L....vii
Sternberg, Geo. M., elected....xiii
Stiles, C. W., Artificial Species of Cestodes....xii
——The Cause of Measly Duck....ix
Sudworth, G. B....iv
Swingle, W. T., Some Problems of Plant Geography in Florida....xi

T.

Tamias alpinus....137
callipeplus....136
minimus pictus....137, 138
panamintus....134, 135
speciosus....137
Teonoma....109, 112
Terebratellidæ....72
Terebratulina....81
Thomomys....113
bottæ....115, 116
bulbivorus....113, 114, 115
Mt. Orizaba....145
orizabæ....145, 146
peregrinus....145, 149
wandering....146
Thompson, J. B., elected....xii
Townsend, C. H., The Propagation of the Atlantic Coast Oyster on the Pacific Coast....vi
——Sea-Otter Fishing in Alaska in Relation to the Natives....vi
——Remarks....vii
Trigonia crenulata....16, 27
stolleyi....16, 26
Trinity division....11, 12, 17
" " fossils....15
Trochus texanus....102
Troglodytes hiemalis....63
True, F. W....iv, xiii
Trullacea....80, 81
Tylostoma pedernalis....17, 33

U.

Ursus americanus....147, 149
cinnamomeus....147
horribilis....149
luteolus....147, 148, 149, 151

V.

Van Deman, H. E....ix
Vanessa cardui....51
Vasey's, George, death....viii
Vermes....16, 21
Vertebrata....17
Vicarya branneri....17, 33
Viviparus (Natica ?) cossatotensis....17, 32

W.

Waite, M. B., The Destruction of Lichens on Pear Trees....vi
——The Variation of the Fruit of the Pear due to Difference of Pollen...vii
——Remarks....v, viii
Walcott, C. D....iv, viii, xiii
Waldheimia....72, 80
bicarinata....74
mawii....74
Ward, L. F., The Flora of the Trinity Division of the Comanche Series in Texas....vi
——The New Botany....x
——Weismann's Concessions....xi
——Remarks, etc....iv, v, vii, viii, xi, xiii
Washita division....10, 11

X.

Xerospermophilus....131

Y.

Yucca....41, 53
aloifolia....43, 47, 53
angustifolia glauca....53
australis....53
baccata....45, 53
brevifolia....53
elata....45, 53
filamentosa....53
filifera....53
gloriosa....53
guatemalensis....53
insects....41, 47
pollination....41
rupicola....45, 53
treculiana....53
whipplei....41, 42, 43, 45, 48, 52, 53
" graminifolia....45, 47, 51

Z.

PAGE
Zapus insignis 1, 2, 3, 4, 6, 8
Zizyphinus 101
Zygospira 71, 72, 75, 76, 77, 78, 80, 81, 82
cincinnatensis 81
deflecta 81
erratica 81
headi 76, 78, 81
kentuckyiensis 81
modesta 76, 78
nicoletti 75, 76, 78, 80, 81
recurvirostra 74, 75, 76, 77, 79, 81
saffordi 75, 76, 78, 81
uphami 8

V. 8-10 Copy 2
24216
Mc 3/10/27

Vol. VIII, pp. 1-8 April 22, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

A JUMPING MOUSE (*ZAPUS INSIGNIS* MILLER) NEW TO THE UNITED STATES

BIOLOGICAL SOCIETY WASHINGTON

BY GERRIT S. MILLER, Jr.

WASHINGTON, D. C.

Published by the Biological Society of Washington

VOL. VIII, PP. 9-40, PLS. I-VIII JUNE 3, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

PALEONTOLOGY OF THE CRETACEOUS FORMATIONS OF TEXAS

THE

INVERTEBRATE PALEONTOLOGY OF THE TRINITY DIVISION

BY

ROBERT T. HILL

WASHINGTON, D. C.

PUBLISHED BY THE BIOLOGICAL SOCIETY OF WASHINGTON

VOL. VIII, PP. 41-54, PL. IX JUNE 20, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

FURTHER NOTES ON

YUCCA INSECTS AND YUCCA POLLINATION

BY

C. V. RILEY, PH. D.

WASHINGTON, D. C.

PUBLISHED BY THE BIOLOGICAL SOCIETY OF WASHINGTON

VOL. VIII, PP. 55-70 JUNE 20, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

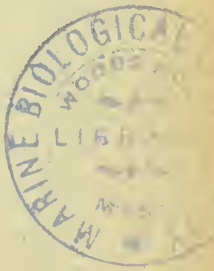
DESCRIPTION

OF A

NEW WHITE-FOOTED MOUSE

FROM THE

EASTERN UNITED STATES



BY

GERRIT S. MILLER, JR.

WASHINGTON, D. C.

PUBLISHED BY THE BIOLOGICAL SOCIETY OF WASHINGTON

VOL. VIII, PP. 71-82, PLS. X, XI JULY 13, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

DEVELOPMENT OF THE BRACHIAL SUPPORTS IN DIELASMA AND ZYGOSPIRA

BY

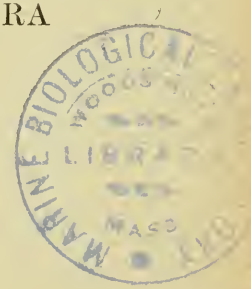
CHARLES E. BEECHER AND CHARLES SCHUCHERT

AND

ON THE DEVELOPMENT OF THE SHELL OF ZYGOSPIRA RECURVIROSTRA

BY

CHARLES SCHUCHERT



WASHINGTON, D. C.

PUBLISHED BY THE BIOLOGICAL SOCIETY OF WASHINGTON

VOL. VIII, PP. 83-96 JULY 18, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

REDISCOVERY

OF

THE MEXICAN KANGAROO RAT

DIPODOMYS PHILLIPSI GRAY

BY

C. HART MERRIAM, M. D.

WITH

FIELD NOTES BY E. W. NELSON

WASHINGTON, D. C.

PUBLISHED BY THE BIOLOGICAL SOCIETY OF WASHINGTON

Vol. VIII, pp. 97-108, pls. XII, XIII July 20, 1893

PROCEEDINGS

OF THE

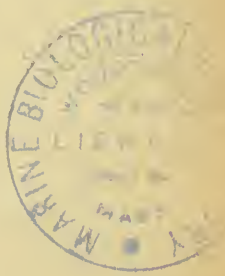
BIOLOGICAL SOCIETY OF WASHINGTON

THE PALEONTOLOGY OF THE CRETACEOUS FORMATIONS OF TEXAS

THE INVERTEBRATE FOSSILS OF THE CAPRINA LIMESTONE BEDS

BY

ROBERT T. HILL



WASHINGTON, D. C.

Published by the Biological Society of Washington